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BEING

OCCASIONAL DISCUSSIONS AND COMPILATIONS OF METEOROLOGICAL DATA

RELATING TO

INDIA AND THE NEIGHBOURING COUNTRIES.

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III—Meteorological History of the seven monsoon seasons, 1893—1899, in relation to the Indian rainfall by W. L. DALLAS, *Esq., Scientific Assistant to the Meteorological Reporter to the Government of India.*

INTRODUCTION.

Between 1893 and 1899 the Meteorological Department of the Government of India collected and collated daily barometer, wind and weather observations for the whole Trades-Monsoon area. From these daily observations I was enabled in 1900 to deduce a series of normal values for the whole area, and it was by means of these charts of normal values that I was in a position to undertake a discussion of the failure of the monsoon rains in India in 1899. This failure of the monsoon rainfall was therein attributed to the deflection of the South-East Trade winds to South Africa, and to the determination of rainfall to that area at the expense of India. It was, however, at the time pointed out that the variations of the surface air movements from the normal were exceedingly slight and appeared inadequate to explain the large failure of the rains over India in 1899. The results were far from conclusive, and I therefore determined to investigate in detail the whole seven monsoon periods from 1893 to 1899.

The investigation was commenced with the ultimate aim of examining all the actions which are ordinarily supposed to determine rain or drought to India and, if possible, to assign to each action or congeries of actions a numerical value which could be utilised in future forecasts of, and investigations into, the Indian monsoon rainfall. As the investigation progressed, however, it appeared to the writer that many of the actions to which an influence on the monsoon rainfall had previously been ascribed, failed to fulfill the functions assigned to them, and the only action which finally remained after the questions, (1) of barometric gradients or differences and (2) of variations in the direction of movement and velocity of movement of the winds, had been thoroughly discussed, was, that which appertained to certain long period oscillations of pressure which the tabulated observations disclosed. The investigation consequently resolved itself more or less into a supplement or adjunct to Mr. Eliot's valuable paper on long period pressure oscillations in India given in Volume VI of the Indian Meteorological Memoirs and the conclusions which are put forward in this paper are merely confirmatory or supplementary to the conclusions which Mr. Eliot enunciated in 1896. From the evidence of the observations discussed in the present paper it is concluded that the explanation of the failure of the 1899 monsoon rains, as put forward in the discussion of that episode, in the above mentioned memoir, was incorrect. There does not, judging from the available data, appear to have been any deflection of the South-East Trades current towards South Africa on that occasion, and it is argued from the evidence of the observations contained in the present investigation, that the excess of rain over South Africa and the failure of the rain over India were a common result of a rapid rise of pressure over the whole Trades-Monsoon area due to the completion of a long period pressure oscillation of large amplitude within the short space of a few months. Following this reasoning through the other six monsoon seasons dealt with in this investigation, the same relation will be found to exist, and

it appears to the writer to follow from a consideration of the whole subject that the variations in the rainfall over the whole Trades-Monsoon area, were, in their main features during the seven seasons under discussion, a function of the pressure oscillations, the signs of the rainfall variations changing at the line of the Equator. Thus it follows that years of very excessive rainfall, as well as years of very deficient rainfall, either in India, or in the South-East Trades region or in any other part of the Trades-Monsoon area, may and do occur without any material alteration in the direction and velocity of the surface air currents. It is not intended to represent this conclusion as anything new or novel, it is merely an extension and amplification of the conclusions stated in Mr. Eliot's paper above referred to, *viz.*, that a south-west monsoon period which is included in the rising portion of a long period oscillation is generally one of deficient rainfall and a south-west monsoon period which is included in the falling portion of a long period oscillation is usually one of increased or excessive rain. The present discussion appears to show that this rule (1) was of general applicability, (2) that it acted irrespective of any other variant, and (3) that it was the main factor in the variation of rainfall from the normal. Therefore, although the present discussion enunciates no new law with regard to rainfall, it will not perhaps be uninteresting to trace the connexion between these pressure oscillations and the rainfall variations throughout the whole Trades-Monsoon area, and to the writer it was an unexpected development to find that to the south of the Equator the relation of the rainfall to the movements of pressure in its oscillations, is the reverse of that existing in regions lying to the north of the Equator. It is due to this reversal that it follows that excessive rain in the South-East Trades region is coincident with deficient rain in India, Arabia and the Nile Valley and *vice versâ*, the excess in the one area and the deficiency in the other being the general effect of a common cause but not bearing the relation of cause and effect.

These conclusions the writer has endeavoured to substantiate in the following paper which gives (1) a brief history of the rainfall of the seven monsoon seasons under review and (2) a discussion of the pressure oscillations and their effects on the rainfall of the Trades-Monsoon area.

The final portion of the paper is concerned with various investigations and enquiries into the relation between pressure differences over the Equatorial and Indian Seas and Indian rainfall, and the relations which variations in the velocity and in the direction of the winds bear to the variations of Indian rainfall. These investigations have yielded no satisfactory results, and the section is only added by way of clearing the ground and in order to show, if possible, that the explanation of the main variations of the Indian monsoon rainfall is to be looked for in investigations into the causes and reasons of the long period pressure oscillations and not in investigations into the variations in the velocity and direction of the surface air currents.

PART I.

BRIEF HISTORY OF THE SEVEN MONSOON SEASONS, 1893—99.

1893. The meteorological conditions in India antecedent to the establishment of the south-west monsoon were not unfavourable. Local pressure conditions were approximately normal and the mean pressure of the whole of India was in slight defect during April and May. Unusually heavy snow had fallen over the North-West Himalayas during January and February, but this precipitation decreased and ceased about the end of March. The air was warmer and clearer than usual over North-West India and the North-West Himalayas during April and the large snow accumulations disappeared during this month. In April and May cyclonic storms formed in the Bay and there was excessive rainfall in Ceylon, Malabar, Tenasserim and the Bay Islands in April and the first-half of May. The following gives data for Colombo, Mangalore, Port Blair and Tavoy for these two months :—

Station.	April.		May.		Period, April and May.	
	Actual rainfall of month.	Variation from normal.	Actual rainfall of month.	Variation from normal.	Variation of actual rainfall of period from normal.	Percentage variation.
	Inches.	Inches.	Inches.	Inches.	Inches.	
Colombo	20·34	+9·06	10·32	— 2·52	+ 6·54	+ 27
Mangalore	2·78	+2·17	11·86	+ 4·09	+ 6·26	+ 75
Port Blair	18·91	+6·73	12·53	— 3·21	+ 3·52	+ 13
Tavoy	9·79	+5·96	33·44	+16·67	+22·63	+110

Consequently in the pre-monsoon period the following were the most prominent features of the weather :—

(1) Not unfavourable conditions over India.

(2) Strong temporary advances of humid winds indicated by heavy rain in the south and by abnormally early cyclonic storms in the Bay.

The permanent advance of the monsoon occurred over the Arabian Sea in the first week of June and over the Bay during the second week of June. Both currents advanced more rapidly than usual into the interior of India and were abnormally strong during June. The Bengal current remained stronger than the average during July, but the Bombay current fell off and was somewhat feebler than the normal. Both currents were very probably below their normal strength and volume during August and the rainfall of India was generally below the normal. During September the monsoon current remained slightly weaker than the average, while the Bay current, on the contrary, increased relatively to the normal and was unusually steady and vigorous. The whole of Northern and Central India received abundant rain in September and the Peninsula normal rain.

The distribution of the south-west monsoon rainfall in 1893 and its variations from

the normal were directly related to the extension and steadiness of the monsoon currents. The deficient rainfall in Burma was due to the larger diversion than usual of the current towards the Gangetic Plain and the Punjab, and a similar explanation holds for the deficient rainfall on the West Coast.

The following gives a summary of the rainfall variation data for the monsoon months June to October :—

Province.	Division.	RAINFALL.									
		June.		July.		August.		September.		October.	
		Actual, 1893.	Variation from normal.	Actual, 1893.	Variation from normal.	Actual, 1893.	Variation from normal.	Actual, 1893.	Variation from normal.	Actual, 1893.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Burma	Tenasserim	30·02	—9·92	37·81	—9·45	48·06	+ 10·25	39·72	+ 15·74	11·81	+ 1·08
	Lower Burma Deltaic	12·77	—6·29	19·14	—3·92	18·65	— 2·10	16·72	+ 3·20	8·18	— 0·82
	Central Burma	10·43	—6·87	16·54	—3·62	15·05	— 2·13	13·06	+ 2·81	6·07	— 0·35
	Upper do.	5·49		7·53		7·17		6·66		8·45	
	Arakan	59·10	+ 6·88	37·36	— 10·96	31·88	— 0·57	21·53	+ 1·09	10·19	+ 0·47
Bengal and Assam.	Eastern Bengal	24·45	+ 5·52	19·15	+ 1·91	16·90	+ 0·41	10·46	— 2·02	7·96	+ 2·48
	Assam Surma	26·79	+ 3·53	34·21	+ 15·21	28·46	+ 7·73	9·73	— 6·73	8·87	+ 3·01
	Do. Brahmaputra.	11·37	— 4·47	18·14	+ 2·50	13·99	+ 0·13	8·93	— 1·85	4·79	+ 1·04
	Deltaic Bengal	19·05	+ 8·39	10·59	— 1·46	9·09	— 3·65	11·63	+ 2·71	5·01	+ 0·40
	Central do.	16·79	+ 6·57	13·47	+ 1·32	8·24	— 3·93	10·90	+ 0·93	4·55	+ 0·65
	North do.	21·53	— 2·09	31·50	+ 11·47	19·37	+ 1·16	18·59	+ 2·52	4·43	— 0·45
	Orissa	8·65	— 0·14	8·37	— 4·13	10·30	— 1·11	15·89	+ 5·63	6·20	+ 0·04
	Chota Nagpur	12·86	+ 5·06	14·25	+ 1·09	10·09	— 3·47	13·83	+ 5·12	4·20	+ 1·23
	South Bihar	9·30	+ 3·51	14·42	+ 2·55	7·68	— 3·59	9·97	+ 2·82	4·01	+ 0·88
	North do.	9·54	+ 0·82	18·48	+ 6·30	9·56	— 1·93	13·66	+ 4·02	4·85	+ 1·27
North-Western Provinces and Oudh.	North-Western Provinces East.	11·19	+ 6·91	11·88	+ 0·04	7·07	— 3·66	13·93	+ 7·06	4·14	+ 1·91
	South Oudh	8·29	+ 3·91	14·08	+ 3·33	6·72	— 3·75	12·52	+ 6·00	3·80	+ 2·20
	North do.	7·98	+ 3·05	13·07	+ 1·98	8·15	— 2·29	9·80	+ 2·58	4·68	+ 3·07
	North-Western Provinces Central.	5·93	+ 2·46	12·72	+ 1·20	6·20	— 4·08	9·89	+ 4·36	1·98	+ 0·89
	North-Western Provinces West.	4·72	+ 2·00	19·04	— 0·88	4·40	— 4·26	5·93	+ 1·14	1·01	+ 0·41
	North-Western Provinces Submontane.	8·59	+ 3·04	4·99	+ 0·38	11·04	— 1·83	11·97	+ 4·55	5·57	+ 4·23
Punjab	South Punjab	1·93	+ 0·53	7·17	+ 2·90	1·24	— 2·20	5·87	+ 3·88	0·12	— 0·03
	Central do.	3·60	+ 1·42	8·97	+ 2·35	2·32	— 2·95	6·47	+ 2·93	0·03	— 0·31
	Punjab Submontane.	6·07	+ 3·23	11·67	+ 2·39	3·72	— 4·61	11·14	+ 7·21	0·01	— 0·37
	Punjab Hills	9·06	+ 4·25	17·19	+ 0·44	7·01	— 9·67	14·20	+ 7·69	0·30	— 0·66
	North-West Punjab.	4·65	+ 3·31	10·44	+ 5·15	2·78	— 2·83	4·52	+ 2·25	0·14	— 0·33
	West Punjab	0·99	+ 0·34	3·50	+ 1·05	0·89	— 1·19	1·49	+ 0·70	0	— 0·11

Province.	Division.	RAINFALL.									
		June.		July.		August.		September.		October.	
		Actual, 1893.	Variation from normal.	Actual, 1893.	Variation from normal.	Actual, 1893.	Variation from normal.	Actual, 1893.	Variation from normal.	Actual, 1893.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Bombay and Malabar Coast Districts (Madras).	Malabar	38·13	+ 0·83	24·79	— 9·63	15·72	— 4·41	8·30	— 2·29	8·84	— 1·20
	Madras South Central.	3·92	+ 1·89	3·73	+ 1·37	1·85	— 1·64	3·47	— 2·13	7·62	+ 1·70
	Coorg	21·12	...	11·55	...	14·71	...	8·98	...	11·52	...
	Mysore	6·09	+ 1·33	4·32	— 3·13	2·48	— 2·84	2·84	— 2·10	8·66	+ 2·88
	Konkan	35·20	+ 8·05	36·67	—13·37	23·54	— 0·42	13·14	— 1·83	4·53	— 0·99
	Bombay Deccan	9·95	+ 4·20	4·75	— 4·54	6·16	+ 0·08	3·75	— 1·69	6·58	+ 1·56
	Khandesh	11·81	+ 6·12	4·92	— 2·75	8·79	+ 2·80	3·77	— 3·30	0·94	— 2·67
Central Provinces and Berar.	Berar	6·18	— 1·21	5·44	— 5·09	11·77	+ 2·83	4·01	— 2·88	3·14	+ 0·58
	Central Provinces West.	8·68	+ 1·20	5·71	— 8·10	13·84	+ 3·97	6·41	— 2·39	2·41	+ 0·33
	Central Provinces Central.	12·18	+ 3·91	10·09	— 7·03	16·60	+ 3·74	12·23	+ 4·28	3·70	+ 1·88
	Central Provinces East.	10·21	+ 2·02	16·30	+ 0·23	14·28	+ 1·75	12·02	+ 4·40	2·66	+ 0·64
Bombay (North).	Gujarat	18·84	+12·58	13·64	— 4·82	8·25	— 1·03	6·12	— 1·91	0·28	— 1·08
	Kathiawar	12·88	+ 9·62	6·61	— 4·66	3·85	— 2·43	6·24	— 1·59	0·18	— 0·57
	Sind	1·63	+ 1·43	1·59	— 0·56	0·01	— 1·93	0·19	— 0·30	0	— 0·35
Rajputana and Central India.	Central India East	10·03	+ 4·01	7·77	— 7·55	10·94	— 1·70	10·38	+ 4·29	1·16	— 0·51
	Rajputana East, Central India West.	4·38	+ 1·47	8·90	— 0·87	6·28	— 3·40	5·88	+ 2·23	0·14	— 0·35
	West Rajputana	3·56	+ 2·35	6·70	+ 3·57	3·72	— 0·76	7·02	+ 5·57	0·02	— 0·06
Madras	East Coast North	5·76	+ 0·86	9·18	+ 2·41	7·40	+ 0·27	9·57	+ 2·73	6·47	— 0·65
	Do. do. A.	7·00	— 3·41	20·42	+ 5·04	16·96	+ 4·21	22·12	+ 13·49	3·78	— 0·98
	Hyderabad South	4·74	+ 0·22	10·20	+ 5·21	11·14	+ 5·17	8·10	+ 3·61	4·06	+ 1·62
	Madras Central	3·51	+ 0·88	5·06	+ 1·89	2·98	— 1·37	3·39	— 2·02	6·39	+ 0·84
	East Coast Central	3·19	+ 1·54	3·11	+ 0·66	0·99	— 2·07	3·60	— 1·09	6·15	— 3·60
	East Coast South	2·86	+ 0·59	5·83	+ 2·82	2·38	— 2·78	3·17	— 1·72	6·30	— 2·07
	Madras South	1·56	+ 0·50	2·33	+ 1·28	0·75	— 1·22	1·46	— 0·83	5·06	— 0·96
	Mean for whole country	11·82	+ 2·24	12·62	— 0·55	10·15	— 0·93	9·38	+ 1·66	4·45	+ 0·41

1894. The meteorological conditions in India in the period antecedent to the establishment of the south-west monsoon were favourable for a strong monsoon. Pressure was in moderate general defect over India during this period and in May there was a large local deficiency in Northern India, greatest in the Gangetic Plain. The cold weather rainfall and snowfall had been heavier than usual, but the precipitation ceased earlier than usual. The winter accumulation of snow melted very rapidly in April and May, and strongly marked hot weather conditions obtained in May. There were slight indications in May of a stronger determination than usual of humid winds from the Equatorial belt northwards to the Indian area. Temporary advances of south-west humid winds occurred earlier than usual in April and May giving rise to cyclonic storms in the Bay. The permanent advance of

the monsoon current occurred in the first week of June in the Arabian Sea and in the second week of June in the Bay. Both currents advanced more rapidly than usual from the coast districts into the interior of Upper India and were stronger than usual during June in which month the whole of India, with the exception of Burma, Assam, North Bengal, the Deccan and South India, received abundant rainfall. During July the rainfall of the month was, on the average of the whole of India, in considerable excess. During June and July the weather was much disturbed and a series of cyclonic storms was developed and the weather was in marked contrast with the conditions prevailing at about the same time in the previous year. During August and September fairly steady monsoon winds prevailed and well distributed rain was received over the greater part of India. The distribution of rain during the south-west monsoon period of 1894 was generally favourable. Rainfall was in slight defect over the greater part of the Peninsula, and also in parts of North-East India, due to the abnormal determination of the Bengal current to Upper India. The rainfall of August and September was complementary to that of June and July, falling most largely in the first period where it was most deficient in the second period.

The following gives a summary of the rainfall variation data for the monsoon months June to October 1894:—

Province.	Division.	Rainfall.									
		June.		July.		August.		September.		October.	
		Actual, 1894.	Variation from normal.	Actual, 1894.	Variation from normal.	Actual, 1894.	Variation from normal.	Actual, 1894.	Variation from normal.	Actual, 1894.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Burma	Tenasserim	55·93	+ 15·88	73·94	+ 26·61	42·94	+ 5·42	42·97	+ 19·40	16·03	+ 5·74
	Lower Burma Deltaic	18·22	— 0·97	31·23	+ 8·20	20·30	— 0·45	14·28	+ 1·00	7·02	— 1·72
	Central do.	13·23	— 2·42	18·30	+ 0·15	18·63	+ 1·62	10·55	+ 0·38	5·28	— 1·37
	Upper do.	4·87	...	9·61	...	8·28	...	7·53	...	5·60	...
	Arakan	39·69	— 12·65	53·18	+ 4·99	40·32	+ 8·32	14·74	— 5·29	8·76	— 0·77
Bengal and Assam.	Eastern Bengal	16·69	— 2·24	20·61	+ 4·01	19·03	+ 2·36	9·50	— 2·98	5·94	+ 0·46
	Assam Surma	34·94	— 2·22	22·54	— 8·77	18·07	— 2·66	18·50	+ 1·96	20·46	+ 14·66
	Do. Brahmaputra	15·36	— 0·14	9·11	— 6·34	16·32	+ 2·46	16·96	+ 6·18	10·72	+ 6·97
	Deltaic Bengal	10·86	+ 0·20	15·08	+ 3·02	11·27	— 1·42	6·53	— 2·39	4·61	+ 0·03
	Central do.	10·05	— 0·17	13·52	+ 1·34	13·28	+ 1·11	10·52	+ 0·57	5·30	+ 1·40
	North do.	19·51	— 4·11	12·76	— 7·27	21·97	+ 2·58	23·87	+ 7·80	9·69	+ 4·75
	Orissa	11·31	+ 2·38	17·33	+ 4·92	9·99	— 1·49	7·00	— 3·19	7·05	+ 0·80
	Chota Nagpur	11·11	+ 3·28	17·17	+ 4·02	18·99	+ 3·32	6·81	— 1·80	6·73	+ 3·88
	South Bihar	7·70	+ 1·91	14·61	+ 2·74	13·96	+ 2·68	9·41	+ 2·27	7·59	+ 4·46
	North do.	8·48	— 0·13	10·65	— 1·57	15·23	+ 3·73	12·40	+ 2·61	6·69	+ 3·11
North-Western Provinces and Oudh.	North-Western Provinces East.	9·43	+ 5·15	13·46	+ 1·65	15·51	+ 4·72	5·88	— 1·01	16·61	+ 14·43
	South Oudh	9·17	+ 4·79	10·39	— 0·36	16·44	+ 5·97	7·00	+ 0·48	15·76	+ 14·16
	North do.	9·18	+ 4·25	12·99	+ 1·30	20·81	+ 10·37	10·40	+ 3·18	11·26	+ 9·65
	North-Western Provinces Central.	9·73	+ 6·26	8·95	— 2·59	14·44	+ 4·12	7·32	+ 1·77	11·25	+ 10·15
	North-Western Provinces West.	5·19	+ 2·47	7·47	— 2·47	11·31	+ 3·12	7·35	+ 2·55	1·57	+ 0·96
	North-Western Provinces Submontane.	9·64	+ 4·09	16·67	+ 2·02	21·53	+ 8·60	9·51	+ 2·11	5·90	+ 4·50

Province.	Division.	RAINFALL.									
		June.		July.		August.		September.		October.	
		Actual, 1894.	Variation from normal.	Actual, 1894.	Variation from normal.	Actual, 1894.	Variation from normal.	Actual, 1894.	Variation from normal.	Actual, 1894.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Punjab	South Punjab	6·27	+ 4·87	5·84	+ 1·57	3·40	— 0·12	2·58	+ 0·59	0	— 0·15
	Central do.	4·29	+ 2·11	5·86	— 0·76	6·67	+ 1·40	6·85	+ 3·31	0	— 0·34
	Punjab Submontane	10·85	+ 8·01	12·41	+ 3·06	9·03	+ 0·70	4·37	+ 0·44	0·02	— 0·36
	Punjab Hills	13·88	+ 9·10	27·13	+ 10·45	23·11	+ 6·44	6·39	— 0·01	0·52	— 0·38
	North-West Punjab	3·16	+ 1·82	8·96	+ 3·65	5·36	— 0·25	2·20	— 0·07	0·04	— 0·43
	West Punjab	1·06	+ 0·41	4·55	+ 2·10	1·14	— 0·96	0·86	+ 0·07	0	— 0·10
Bombay and Malabar Coast districts (Madras).	Malabar	32·79	— 4·51	29·30	— 5·12	28·26	+ 8·13	8·35	— 1·85	7·14	— 2·90
	Madras South Central	1·17	— 0·86	2·39	+ 0·03	4·93	+ 1·44	3·17	— 1·15	7·05	+ 1·13
	Coorg	16·67		22·37		15·45		5·36		7·97	
	Mysore	2·50	— 2·37	5·17	— 2·30	4·67	— 0·64	1·55	— 3·39	5·96	+ 0·21
	Konkan	25·29	— 1·86	48·82	+ 8·78	19·10	— 5·05	13·32	— 1·65	6·69	+ 1·14
	Bombay Deccan	5·38	— 0·37	12·53	+ 3·24	5·24	— 0·77	4·37	— 1·17	4·90	— 0·12
	Khandesh	5·23	— 0·46	13·62	+ 5·95	2·68	— 3·31	10·11	+ 3·04	4·48	+ 0·87
	Berar	7·22	— 0·60	13·04	+ 3·91	2·81	— 6·08	10·22	+ 3·40	4·09	+ 1·60
Central Provinces and Berar.	Central Provinces West.	8·41	+ 0·92	14·90	+ 1·09	7·98	— 1·89	14·28	+ 5·48	5·09	+ 3·01
	Central Provinces Central.	10·76	+ 2·54	17·33	— 0·69	13·32	+ 0·46	9·99	+ 2·04	4·79	+ 2·94
	Central Provinces East.	9·86	+ 1·67	22·53	+ 6·46	15·72	+ 3·19	8·45	+ 0·83	4·47	+ 2·45
Bombay (North).	Gujarat	10·74	+ 4·48	29·63	+ 11·17	4·32	— 4·96	10·65	+ 2·62	6·54	+ 5·18
	Kathiawar	9·68	+ 6·42	24·99	+ 12·60	2·01	— 4·27	5·34	+ 0·64	2·98	+ 2·29
	Sind	0·24	+ 0·04	7·15	+ 5·29	0·19	— 1·75	0·05	— 0·44	0	— 0·03
Rajputana and Central India.	Central India East	9·75	+ 3·73	12·59	— 2·73	9·80	— 2·84	8·38	+ 1·69	5·61	+ 4·03
	Rajputana East, Central India West.	6·47	+ 3·39	8·80	— 0·97	8·72	— 0·95	4·76	+ 1·11	0·14	— 0·36
	West Rajputana	3·91	+ 2·34	5·21	+ 1·88	2·68	— 1·80	2·09	+ 0·74	0·03	+ 0·05
Madras	East Coast North	5·81	+ 0·91	7·85	+ 1·14	5·76	— 1·10	7·33	+ 0·39	11·18	+ 4·01
	Do. do. A.	9·33	— 1·08	17·50	+ 2·12	9·07	— 3·68	9·59	+ 0·96	12·92	+ 8·16
	Hyderabad South	1·54	— 2·96	4·64	— 2·02	5·95	+ 0·14	9·69	+ 5·24	4·44	+ 2·08
	Madras Central	1·05	— 1·58	3·56	— 0·39	7·19	+ 2·84	3·38	— 2·02	6·16	+ 0·61
	East Coast Central	1·05	— 0·60	1·83	— 0·62	5·09	+ 2·03	3·53	— 0·08	11·30	+ 1·55
	East Coast South	0·88	— 1·39	2·18	— 0·82	7·37	+ 2·21	5·76	+ 0·90	6·72	— 1·62
	Madras South	0·39	— 0·67	0·60	— 0·48	2·69	+ 0·67	1·86	— 0·37	5·89	— 0·15
	Mean for whole country	10·87	+ 1·09	15·47	+ 1·93	12·16	+ 1·08	8·73	+ 1·19	6·40	+ 2·61

1895. The meteorological conditions over the Indian land area antecedent to the establishment of the monsoon were, as in 1894, favourable for a strong monsoon. Pressure was in moderate general defect during the period, the chief feature of the pressure distribution of May having been a largish local deficiency in Northern India—greatest

over the Gangetic Plain. The cold weather rainfall over North-West India and the snowfall over the North-West Himalayas had been about normal, but the precipitation ceased unusually early, (about the middle of February), and the winter accumulation melted very rapidly during March and the snow-clad surface was considerably below the normal at the end of May. Ordinary hot weather conditions obtained over India in March and April and strongly marked hot weather conditions in May. There were, however, indications in May of a feebler determination than usual of humid winds from the Equatorial belt northwards towards India. Consequently in the pre-monsoon period the following were the most prominent features of the weather ;—

(1) Very favourable conditions over India.

(2) Indications of feeble and late advance of the humid currents from Equatorial regions.

The Bombay current was considerably delayed, appearing on the Malabar Coast about a fortnight later and on the Bombay coast about a week later than usual. The Bengal current advanced across the coast in the third week of June. Both currents extended rapidly into the interior and general rain fell over the whole of North-Western and Central India before the end of the month. Both currents were determined more strongly than usual to North-West India, and the central parts of the country, and North-West India received more rain than usual, while parts of Burma and of North-East India had a large deficiency. The Bombay current was weak during the greater part of July and the rainfall was deficient over a considerable part of Western, Central and North-Western India, while the Bengal current was also weak and irregular, though giving heavy rain to Assam. The Bombay current was strong during the first half of August, but feeble during the second half. The Bengal current was strong throughout the month. The rainfall was irregularly distributed and was in defect over a large part of Western and North-Western India. In September the Bombay current was weak throughout the month, having withdrawn from Upper India about the end of August, and the Bay current was slightly weaker than usual. Consequently the rainfall was in excess over the Peninsula, in defect elsewhere, and practically altogether absent from the extreme north-west of India.

The following gives a summary of the rainfall variation data for the monsoon months June to October 1895 :—

Province.	Division.	Rainfall.									
		June.		July.		August.		September.		October.	
		Actual, 1895.	Variation from normal.	Actual, 1895.	Variation from normal.	Actual, 1895.	Variation from normal.	Actual, 1895.	Variation from normal.	Actual, 1895.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Burma	Tenasserim	41·58	+ 1·09	33·63	— 13·44	44·77	+ 7·54	24·91	+ 1·74	6·24	—3·59
	Lower Burma Deltaic	20·66	+ 1·57	19·05	— 3·96	20·30	— 0·31	15·30	+ 2·27	6·34	—1·98
	Central Burma	11·29	— 4·21	10·71	— 1·38	11·84	— 1·10	8·27	— 0·41	3·25	—2·50
	Upper do.	6·12		4·61		6·26		8·25		1·99	
	Arakan	26·99	—25·71	36·25	— 11·77	33·57	+ 2·02	17·52	— 2·09	4·90	—4·24

Province.	Division.	RAINFALL.									
		June.		July.		August.		September.		October.	
		Actual, 1895.	Variation from normal.	Actual, 1895.	Variation from normal.	Actual, 1895.	Variation from normal.	Actual, 1895.	Variation from normal.	Actual, 1895.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Bengal and Assam.	Eastern Bengal	9·05	— 9·91	15·02	— 2·22	16·37	— 0·30	10·79	— 1·69	5·75	+ 0·27
	Assam Surma	14·74	— 8·52	48·84	+ 18·04	20·46	— 0·27	19·39	— 4·14	6·17	+ 0·31
	Do. Brahmaputra	9·38	— 6·46	23·00	+ 7·80	14·74	+ 0·88	10·68	+ 0·41	1·94	— 1·81
	Deltaic Bengal	8·71	— 1·91	7·41	— 4·64	8·99	— 3·71	5·43	— 3·49	4·51	— 0·10
	Central Do.	6·80	— 3·40	10·71	— 1·34	8·56	— 3·58	6·99	— 2·98	1·83	— 2·07
	North Do.	10·91	— 13·52	34·07	+ 13·47	19·29	+ 0·19	13·52	— 2·55	1·81	— 3·07
	Orissa	20·08	+ 11·23	10·36	— 2·14	13·68	+ 2·27	9·38	— 0·87	5·35	— 0·81
	Chota Nagpur	9·95	+ 1·70	13·52	— 0·15	11·06	— 3·93	6·00	— 2·59	2·82	— 0·05
	South Bihar	4·98	— 0·77	13·68	+ 1·81	10·86	— 0·33	5·55	— 1·60	0·28	— 2·85
	North Do.	6·27	— 2·34	15·58	+ 3·40	14·56	+ 3·00	8·85	— 0·79	0·43	— 3·15
North-Western Provinces and Oudh.	North-Western Provinces East.	6·17	+ 1·88	11·54	— 0·29	9·35	— 1·44	5·50	— 1·39	0·03	— 2·15
	South Oudh	6·25	+ 1·86	11·06	+ 0·31	9·21	— 1·26	6·22	— 0·30	0·07	— 1·53
	North Do.	9·01	+ 4·08	10·44	— 1·25	10·30	— 0·14	7·24	+ 4·79	0·02	— 1·59
	North-Western Provinces Central.	8·11	+ 4·64	8·48	— 3·05	9·27	— 1·10	2·83	— 2·70	0·01	— 1·09
	North-Western Provinces West.	5·87	+ 3·13	7·03	— 2·91	9·14	+ 0·45	1·99	— 2·81	0	— 0·61
	North-Western Provinces Submontane.	10·16	+ 4·60	12·74	— 1·89	15·95	+ 3·13	4·31	— 3·03	0·06	— 1·31
Punjab	South Punjab	2·55	+ 1·15	2·12	— 2·15	4·50	+ 1·06	0·03	— 1·96	0·01	— 0·13
	Central Do.	3·44	+ 1·26	4·04	— 2·58	4·72	— 0·55	0·41	— 3·13	0	— 0·34
	Punjab Sub-montane	4·21	+ 1·37	3·16	— 6·19	10·38	+ 2·05	0·14	— 3·79	0·04	— 0·34
	Punjab Hills	11·74	+ 6·96	11·84	— 4·84	19·40	+ 1·84	2·74	— 3·66	0·34	— 0·56
	North-West Punjab	3·69	+ 2·35	2·26	— 3·03	7·14	+ 1·53	0·39	— 1·88	0·17	— 0·30
	West Punjab	1·79	+ 1·15	1·55	— 0·90	3·59	+ 1·49	0·17	— 0·62	0·01	— 0·08
Bombay and Malabar Coast districts (Madras).	Malabar	39·37	+ 2·07	40·92	+ 6·50	17·40	— 2·73	4·69	— 5·51	11·35	+ 1·31
	Madras South Central	1·74	— 0·29	2·05	— 0·31	5·33	+ 1·84	6·49	+ 2·17	7·91	+ 1·99
	Coorg	29·03		22·22		16·44		4·55		6·80	
	Mysore	5·38	+ 0·51	4·33	— 3·11	4·26	— 1·04	5·08	+ 0·14	6·29	+ 0·56
	Konkan	23·96	— 3·19	37·71	— 2·25	24·63	+ 0·48	9·91	— 5·06	5·38	— 0·17
	Bombay Deccan	5·81	+ 0·06	6·73	— 2·56	5·25	— 1·02	9·65	+ 4·17	4·73	— 0·29
	Khandesh	5·59	— 0·10	8·07	+ 0·40	4·47	— 1·52	9·52	+ 2·45	1·79	— 1·82
Central Provinces and Berar.	Berar	6·37	— 0·80	6·58	— 4·81	5·11	— 3·78	5·32	— 1·09	1·33	— 1·25
	Central Provinces West.	11·77	+ 4·28	8·91	— 3·67	11·68	+ 1·81	4·36	— 4·44	0·67	— 1·28
	Central Provinces Central.	13·23	+ 5·01	11·39	— 6·78	13·92	+ 1·05	2·78	— 5·17	0·69	— 1·02
	Central Provinces East.	16·47	+ 8·28	12·15	— 3·48	15·82	— 1·71	3·06	— 4·56	0·72	— 1·1

Province.	Division.	RAINFALL.									
		June.		July.		August.		September.		October.	
		Actual, 1895.	Variation from normal.	Actual, 1895.	Variation from normal.	Actual 1895.	Variation from normal.	Actual, 1895.	Variation from normal.	Actual, 1895	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Bombay (North).	Gujarat	6·19	— 0·07	13·42	— 6·12	9·08	— 0·20	3·13	— 4·90	1·67	+ 0·31
	Kathiawar	3·78	+ 0·52	8·87	— 3·52	6·55	+ 0·27	1·14	— 3·56	1·12	+ 0·43
	Sind	0·21	0	0·44	— 1·42	4·25	+ 2·12	0·02	— 0·47	0·09	+ 0·06
Rajputana and Central India.	Central India East	8·40	+ 2·52	8·05	— 0·84	9·29	— 3·13	2·98	— 3·58	0·36	— 1·25
	Rajputana East, Central India West.	2·68	— 0·39	6·65	— 3·23	8·21	— 1·52	0·86	— 2·78	0·05	— 0·45
	West Rajputana	1·01	— 0·56	2·75	— 0·58	3·81	— 0·67	0·16	— 1·19	0·02	— 0·06
Madras	East Coast North	7·90	+ 3·00	9·31	+ 2·57	10·54	+ 3·36	9·09	+ 2·18	8·58	+ 1·46
	Do. do. (*a*)	15·83	+ 5·42	15·66	+ 0·28	13·86	+ 1·11	9·82	+ 1·19	3·75	— 1·01
	Hyderabad South	3·76	— 0·76	4·64	— 0·25	7·49	+ 1·68	8·56	+ 4·15	5·03	+ 2·76
	Madras Central	2·24	— 0·39	3·25	+ 0·10	2·78	— 1·57	7·73	+ 2·37	6·57	+ 1·02
	East Coast Central	1·58	— 0·07	2·10	— 0·35	3·35	+ 0·29	5·28	+ 1·67	10·83	+ 1·08
	East Coast South	0·84	— 1·43	3·59	+ 0·59	6·49	+ 1·33	7·64	+ 2·78	11·84	+ 3·50
	Madras South	0·81	— 0·25	0·49	— 0·59	2·48	+ 0·46	2·40	+ 0·17	10·85	+ 4·81
	Mean for whole country	9·53	— 0·33	12·15	— 1·28	11·17	+ 0·07	6·42	— 1·18	3·24	— 0·52

1896. The pre-monsoon meteorological conditions over India were favourable for a strong monsoon and also for its rapid extension into Upper India. The cold weather rainfall and snowfall had been normal or slightly to considerably below the normal in the Punjab and the North-West Himalayas, and the winter precipitation ceased unusually eary (about the middle of February). The winter accumulation of snow was small in amount and melted very rapidly in March and April. Hence the hot weather conditions set in early in March and April and were very strongly marked in May when temperature was largely in excess of the average. Pressure was in moderate defect over the Indian land area during this period and there was a largish local deficiency of pressure over Northern India, greatest in the Gangetic Plain. Conditions were thus favourable over India for the advance of the monsoon. There were, however, indications in May of a feebler determination than usual of humid winds from the Equatorial belt northwards to India. The monsoon commenced on the Malabar and Konkan Coasts on the 13th June and in Bengal on the 18th. Both currents advanced rapidly over the country but the monsoon was weak, more especially the Bengal current. The rainfall was deficient over Burma and North-East India and normal or in excess elsewhere. In July the monsoon currents were normal or above their normal strength and the rainfall of the month was more or less in excess across the head of the Peninsula and in Gujarat and Kathiawar, but was generally in slight defect in Southern India and in moderate to large defect in Northern India. The Bengal current was moderately strong throughout the month of August, while the Bombay current was strong except during the last ten days. The rainfall of the

month was in excess in Burma, the West Coast and across the head of the Peninsula, but was in defect over North-Eastern, Central and North-Western India and in the south of Madras. The monsoon withdrew from the whole of North-Western and Central India in the third and fourth weeks. September 1896 was an abnormally dry month over the greater part of the interior of India owing to the weakness of the monsoon currents. The rainfall of the month was in excess in Tenasserim, Lower Burma, East and North Bengal and South Madras, but was in defect elsewhere—more particularly in North-West and Central India and on the West Coast. The following gives the tabular statement of the monsoon rainfall for the months June to October 1896:—

Province.	Division.	Rainfall. June. Actual, 1896.	June. Variation from normal.	July. Actual, 1896.	July. Variation from normal.	August. Actual, 1896.	August. Variation from normal.	September. Actual, 1896.	September. Variation from normal.	October. Actual, 1896.	October. Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Burma	Tenasserim	49·41	+ 8·23	44·37	— 2·19	53·15	+ 16·35	29·20	+ 7·01	9·25	+ 0·31
	Lower Burma Deltaic	23·06	+ 3·61	28·49	+ 5·49	29·19	+ 9·00	20·64	+ 7·66	8·04	+ 0·24
	Central Burma	9·09	— 3·63	13·57	— 0·66	15·02	+ 2·15	7·33	— 1·48	4·91	— 0·22
	Upper do.	10·26		4·91		6·04		7·40		2·71	
	Arakan	40·27	— 12·60	55·29	+ 7·79	53·72	+ 23·33	20·76	+ 1·73	5·01	— 3·57
Bengal and Assam	Eastern Bengal	15·40	+ 0·42	12·17	— 4·84	7·26	— 8·84	13·23	+ 2·26	0·54	— 5·00
	Assam Surma	18·37	— 7·25	15·59	— 3·41	18·09	— 6·99	17·47	— 0·26	0·56	— 4·97
	Do. Hills	16·46	— 15·32	24·85	+ 1·67	15·67	— 11·05	19·30	— 1·14	1·64	— 4·17
	Do. Brahmaputra	10·08	— 6·28	16·00	— 0·03	12·99	— 0·97	8·23	— 1·61	1·21	— 2·11
	Deltaic Bengal	13·81	+ 3·12	11·84	+ 0·03	8·35	— 3·84	8·01	— 0·49	0·09	— 4·42
	Central do.	11·45	+ 1·31	10·62	— 1·73	7·35	— 3·99	7·89	— 1·50	0·05	— 3·47
	North do.	7·06	— 14·08	18·02	— 1·66	7·39	— 9·39	18·52	+ 3·14	1·69	— 2·85
	Bengal Hills	15·45	— 11·77	26·25	— 9·22	22·37	— 3·71	20·15	+ 1·12	2·33	— 3·83
	Orissa	14·93	+ 5·73	15·07	+ 3·40	15·62	+ 3·64	8·81	— 1·89	0·09	— 5·76
	Chota Nagpur	12·48	+ 4·09	17·04	+ 2·90	12·64	— 1·14	4·99	— 3·43	0	— 2·92
	South Bihar	7·03	+ 0·89	9·61	— 2·64	9·63	— 2·18	5·59	— 1·40	0·01	— 2·59
	North do.	5·49	— 3·71	11·30	— 2·45	6·28	— 4·34	6·25	— 3·35	0·06	— 2·73
North-Western Provinces and Oudh.	North-Western Provinces East.	5·59	+ 1·30	8·36	— 3·47	8·27	— 2·52	0·75	— 6·14	0	— 2·16
	South Oudh	4·04	— 0·35	5·83	— 4·87	6·98	— 3·49	0·11	— 6·41	0·02	— 1·58
	North do.	5·65	+ 0·72	6·40	— 5·29	15·93	+ 5·54	0·53	— 6·69	0·02	— 1·59
	North-Western Provinces Central.	4·26	+ 0·73	7·85	— 3·94	6·20	— 4·35	0·38	— 5·12	0·01	— 1·03
	North-Western Provinces West.	2·61	+ 0·26	0·62	+ 0·77	4·27	— 3·43	0·20	— 4·42	0	— 0·51
	North Western Provinces East Submontane.	4·74	— 0·80	7·61	— 4·89	10·39	— 0·39	1·04	— 6·87	0	— 2·87
	North-Western Provinces West Submontane.	7·29	+ 2·13	10·18	— 4·49	14·89	+ 1·78	0·56	— 6·55	0·05	— 0·78
	North-Western Provinces Hills.	12·26	+ 4·73	12·05	— 5·01	17·91	+ 1·39	0·93	— 6·85	0·13	— 1·35

Province.	Division.	RAINFALL.									
		June.		July.		August.		September.		October.	
		Actual, 1896.	Variation from normal.	Actual, 1896.	Variation from normal.	Actual, 1896.	Variation from normal.	Actual, 1896.	Variation from normal.	Actual, 1896.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Punjab	South-East Punjab	1·86	— 0·63	7·30	— 0·38	4·24	— 1·67	0·35	— 3·85	0·08	— 0·28
	South do.	0·89	— 0·73	2·77	— 2·10	3·68	— 0·45	0·49	— 1·89	0·17	— 0·04
	Central Punjab	1·21	— 0·33	2·74	— 2·25	4·53	— 0·22	0·54	— 1·79	0·10	0·39
	Punjab Submontane	3·29	+ 1·04	5·54	— 3·66	8·56	+ 0·31	0·57	— 3·19	0·11	— 0·27
	Punjab Hills	8·24	+ 3·46	11·94	— 4·74	17·55	+ 0·88	1·52	— 4·88	0·05	— 0·23
	North Punjab	0·99	+ 0·10	3·38	— 0·79	4·56	— 0·22	1·21	— 0·73	0·17	— 0·31
	West do.	0·57	— 0·10	2·07	— 0·50	1·77	— 0·30	0·32	— 0·77	0·08	— 0·04
Bombay and Malabar Coast Districts (Madras).	Malabar	46·48	+ 9·18	38·39	+ 3·97	33·65	+13·52	4·47	— 5·73	6·19	— 3·85
	Travancore	22·55		16·31		10·38		3·05		8·77	
	Madras South Central	3·09	+ 1·06	0·85	— 1·51	1·96	— 1·53	8·13	+ 3·81	4·51	— 1·39
	Coorg	45·97		45·78		22·75		6·11		4·66	
	Mysore	8·39	+ 3·41	7·51	+ 0·12	5·37	+ 0·23	4·44	— 0·47	2·08	— 3·59
	Konkan	29·58	+ 2·71	51·91	+ 11·87	37·43	+ 12·42	3·05	— 11·92	1·08	— 4·41
	Bombay Deccan	9·04	+ 3·23	13·46	+ 4·07	9·10	+ 2·96	1·20	— 4·33	0·81	— 4·19
	Khandesh	8·44	+ 2·75	16·61	+ 8·95	5·48	— 0·51	0·69	— 6·38	0·24	— 3·37
Central Provinces and Berar.	Berar	5·89	— 1·35	11·17	— 0·42	6·92	— 1·97	0·38[1]	— 5·85	0·03	— 2·29
	Central Provinces West	10·05	+ 2·56	14·86	+ 1·05	16·44	+ 6·57	0·61	— 8·22	0	— 1·73
	Central Provinces Central.	11·03	+ 2·81	17·51	— 0·51	21·36	+ 8·50	1·29	— 6·66	0	— 1·37
	Central Provinces East	15·71	+ 7·52	24·36	+ 8·29	22·24	+ 9·71	3·14	— 4·48	0	— 1·49
Bombay (North).	Gujarat	8·28	+ 2·02	23·91	+ 5·45	12·81	+ 3·53	1·75	— 6·28	0	— 1·36
	Kathiawar	7·00	+ 3·74	11·53	+ 0·26	8·98	+ 2·70	0·51	— 4·19	0	— 0·69
	Sind	0·60	+ 0·39	0·45	— 1·41	2·14	+ 0·20	0·01	— 0·48	0	— 0·03
	Baluchistan Hills	1·08	+ 1·01	0·54	+ 0·01	0·79	+ 0·36	0·08	+ 0·02	0·04	— 0·01
Rajputana and Central India.	Central India East	6·97	+ 0·95	10·88	— 4·01	10·97	— 1·40	0·44	— 6·12	0	— 1·66
	Rajputana East and Central India West.	3·41	+ 0·34	7·96	— 1·92	6·32	— 3·41	0·51	— 3·13	0·03	— 0·47
	West Rajputana	2·77	+ 1·20	3·91	+ 0·58	2·83	— 1·65	0·14	— 1·21	0·02	— 0·06
Madras	East Coast North	5·21	+ 0·33	7·18	+ 0·43	8·32	+ 1·24	5·03	— 1·97	0·16	— 6·96
	Do. do. (a)	9·95	— 0·461	13·44	— 1·94	26·75	+ 14·00	7·88	— 0·75	0	— 4·76
	Hyderabad South	2·48	— 2·10	3·75	— 1·07	6·83	+ 0·98	2·35	— 1·98	0·01	— 2·08
	Madras Central	2·03	— 0·60	2·09	— 1·06	3·30	— 0·80	2·38	— 2·98	0·36	— 4·85
	East Coast Central	0·95	— 0·70	2·79	+ 0·34	5·29	+ 2·23	5·88	+ 2·27	1·23	— 8·52
	East Coast South	1·28	— 0·59	1·30	— 1·70	3·74	— 1·42	5·77	+ 0·91	4·03	— 4·31
	Madras South	1·59	+ 0·53	1·09	+ 0·01	0·55	— 1·47	4·35	+ 2·12	7·31	+ 1·27
	Mean for whole country	10·63	+ 0·46	13·46	— 0·08	12·01	+ 1·11	4·94	— 2·48	1·47	— 3·23

1897. The meteorological conditions in the Indian land area antecedent to the establishment of the south-west monsoon were favourable to a normal monsoon and also to its rapid extension over India. The snowfall of the winter had been normal or in defect in the Eastern and Central Himalayas, but the winter was more prolonged than usual in the Punjab Himalayas and there had been frequent and heavy falls of snow in March and April. The snowfall was unusually heavy in North Kashmir and Central and North Afghanistan and there was an excessive fall between the beginning of March and the beginning of May in Chitral and Kashmir. The pressure conditions in India generally were favourable. There was, however, a tendency to higher pressure than usual in the Punjab, West Rajputana, Sind and Gujarat, exhibited slightly in the first three months of the year, but strongly in April. This accumulation of pressure was undoubtedly a result of the excessive snow in the North Punjab. The temperature conditions were favourable and the air movement was more vigorous than usual. The advance of the monsoon current over the Arabian Sea was somewhat delayed, occurring on the Bombay Coast about the 12th or 13th. The current advanced rapidly into the interior, but was below its normal strength throughout June. The Bay current was established about the normal date and advanced quickly inland. The rainfall in June was in defect over the greater part of the country but was in excess in Lower Burma, West Bengal, the North-Western Provinces and the west and north of the Punjab. The monsoon currents were also below their normal strength in July and there were breaks in the rains at the beginning and end of the month. The total rainfall of the month was in excess in Malabar, the Konkan and the hills and western divisions of the North-Western Provinces and was generally in defect elsewhere. The deficiency was most marked in the Central Provinces, the Bombay Deccan, Hyderabad, Gujarat, parts of Bengal, the Punjab and Central India. The monsoon currents increased and were practically of normal strength in August and September, and the rainfall of these two months was unusually well distributed. In August the monsoon currents penetrated to their extreme limits in the North Punjab and Baluchistan, and the rainfall was in excess in practically all parts of the country except parts of Bengal. The rainfall of the month of September was in defect in Burma, the North-Western Provinces, the Punjab and parts of Central India and of Rajputana, and was generally in excess elsewhere, more particularly over the Peninsula. The following gives a tabular statement of the monsoon rainfall for the months June to October of 1897:—

Province.	Division.	Rainfall.									
		June.		July.		August.		September.		October.	
		Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Burma	Tenasserim	30·81	+ 0·52	40·67	— 6·44	41·19	+ 2·79	17·52	— 7·87	15·31	+ 6·48
	Lower Burma Deltaic	13·12	+ 2·93	20·12	— 3·37	24·96	+ 4·23	11·19	— 2·75	10·22	+ 1·28
	Central do.	8·22	— 2·12	11·41	— 0·17	14·17	+ 0·61	6·97	— 1·98	9·42	+ 3·02
	Upper do.	2·73	— 2·74	5·38	— 1·86	8·61	— 1·68	5·45	— 3·30	5·41	— 0·03
	Arakan	44·68	+ 3·70	43·51	— 4·88	48·54	+ 15·19	22·37	+ 1·23	12·51	+ 2·29

Province.	Division.	RAINFALL.									
		June.		July.		August.		September.		October.	
		Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Bengal and Assam.	Eastern Bengal	16·15	— 0·89	14·89	— 3·12	19·79	+ 3·57	14·57	+ 3·93	7·29	+ 1·74
	Assam Surma	24·53	+ 6·66	16·39	— 2·61	28·95	+ 6·03	18·68	+ 2·22	4·30	— 1·56
	Do. Hills	15·68	— 2·69	19·04	— 5·89	22·60	— 4·23	39·56	+ 18·89	9·15	+ 1·33
	Do. Brahmaputra	7·22	— 4·41	17·89	+ 1·86	14·14	+ 0·48	16·70	+ 5·57	6·40	+ 2·44
	Deltaic Bengal	13·36	+ 2·70	10·45	— 1·36	13·46	+ 1·27	7·40	— 1·10	7·58	+ 3·07
	Central do.	9·59	— 0·43	8·34	— 3·95	12·33	+ 1·02	9·79	+ 10·56	7·15	+ 3·59
	North do.	13·36	— 7·78	16·86	— 2·82	15·89	— 6·89	22·61	+ 7·23	7·91	+ 3·37
	Bengal Hills	20·01	— 10·36	27·04	— 8·43	23·87	— 4·11	21·50	+ 1·97	9·43	+ 3·27
	Orissa	7·85	— 1·35	13·20	+ 1·53	11·20	— 0·78	8·36	— 2·34	10·50	+ 4·65
	Chota Nagpur	7·08	— 1·26	13·11	— 1·04	15·56	+ 1·69	7·01	— 1·19	5·79	+ 2·90
	South Bihar	12·21	+ 6·09	13·27	+ 0·98	12·48	+ 0·74	6·07	— 0·89	5·88	+ 3·28
	North do.	9·68	+ 0·79	9·84	— 3·76	10·99	— 1·61	10·33	+ 0·88	7·76	+ 4·92
North-Western Provinces and Oudh.	North-Western Provinces East.	5·74	+ 1·45	10·06	— 1·77	20·02	+ 9·23	3·99	— 2·90	6·77	+ 4·59
	South Oudh	3·58	— 0·81	10·07	— 0·68	18·32	+ 7·85	4·71	— 1·81	0·72	— 0·88
	North do.	4·67	— 0·26	13·06	+ 1·37	13·85	+ 3·41	7·04	— 0·18	1·14	— 0·47
	North-Western Provinces Central.	4·74	+ 1·21	9·78	— 2·02	12·47	+ 1·92	4·07	— 1·43	0·32	— 0·72
	North-Western Provinces West.	2·45	+ 0·10	13·39	+ 4·54	9·60	+ 1·90	4·09	— 0·53	0·08	— 0·46
	North-Western Provinces East Submontane.	6·95	+ 1·41	11·93	— 0·57	13·11	+ 2·33	7·30	— 0·61	6·68	+ 3·81
	North-Western Provinces West Submontane.	3·00	— 2·16	19·38	+ 4·71	15·96	+ 2·85	8·07	+ 0·77	0·06	— 0·77
	North-Western Provinces Hills.	5·44	— 2·09	27·42	+ 10·36	18·59	+ 2·67	15·56	+ 7·62	0·35	— 1·16
Punjab.	South-East Punjab	1·76	— 0·73	7·41	— 0·27	6·78	+ 0·87	2·33	— 1·87	0·06	— 0·30
	South do.	0·77	— 0·85	4·08	— 0·79	5·57	+ 1·44	1·69	— 0·69	0·16	— 0·05
	Central do.	1·32	— 0·26	2·87	— 2·12	6·70	+ 1·95	0·96	— 1·37	0·01	— 0·34
	Punjab Submontane	1·18	— 1·61	6·71	— 2·59	8·83	+ 0·58	2·55	— 1·21	0·03	— 0·33
	Punjab Hills	3·22	— 1·56	12·54	— 4·14	18·58	+ 1·91	7·40	+ 1·00	0·12	— 0·78
	North Punjab	1·39	+ 0·63	3·47	— 0·66	7·78	+ 3·00	1·57	— 0·37	0·08	— 0·38
	West do.	1·04	+ 0·37	2·30	— 0·27	5·53	+ 3·46	0·86	— 0·08	0·02	— 0·09
Bombay and Malabar Coast Districts (Madras).	Malabar	44·51	+ 7·21	48·77	+ 14·35	33·69	+ 13·56	14·10	+ 4·34	8·48	— 1·56
	Travancore	26·30		17·68		18·57		10·36		7·51	
	Madras South Central	1·97	— 0·06	1·57	— 0·79	5·89	+ 2·40	9·71	+ 5·39	4·14	— 1·78
	Coorg	25·44		33·38		33·55		9·21		7·93	
	Mysore	5·83	+ 1·12	5·41	— 2·00	7·32	+ 2·11	9·97	+ 5·09	3·60	— 1·91
	Konkan	22·39	— 4·75	51·65	+ 11·61	28·74	+ 4·78	16·20	+ 1·23	6·57	+ 1·05
	Bombay Deccan	5·76	— 0·04	7·98	— 1·41	7·00	+ 0·86	8·19	+ 2·66	4·87	— 0·13
	Hyderabad North	3·66	— 2·11	6·46	— 2·00			9·66	+ 2·11	1·78	— 0·97
	Khandesh	2·50	— 3·19	8·04	+ 0·41	7·69	+ 1·70	10·80	+ 3·73	2·08	— 1·53
Central Provinces and Berar.	Berar	1·73	— 4·25	9·84	— 1·75	10·29	+ 1·40	6·98	+ 0·36	0·72	— 1·77
	Central Provinces West.	4·28	— 3·21	12·88	— 0·93	15·52	+ 5·65	7·78	— 1·05	0·99	— 1·09
	Central Provinces Central.	4·43	— 3·79	11·66	— 6·36	17·38	+ 4·52	7·80	— 0·15	1·25	— 0·60
	Central Provinces East	5·42	— 2·89	12·28	— 3·79	17·79	+ 5·25	7·36	— 0·21	4·67	+ 2·61

Province.	Division.	RAINFALL.									
		June.		July.		August.		September.		October.	
		Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.	Actual, 1897.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Bombay (North).	Gujarat	2·34	−3·92	11·82	−6·64	13·32	+ 3·86	6·72	−1·31	0·68	−0·68
	Kathiawar	1·35	−1·91	9·12	−2·15	11·14	+ 4·86	6·35	+1·65	1·08	+0·39
	Sind	0	−0·20	1·93	+0·07	4·80	+ 2·86	1·26	+0·77	0	−0·03
	Baluchistan Hills	0·09	−0·35	0·85	−0·14	2·23	+ 1·48	0·11	−0·04	0	−0·10
Rajputana and Central India.	Central India East	5·34	−1·18	9·59	−4·12	14·32	+ 2·04	5·04	−2·03	0·78	−0·73
	Rajputana East, and Central India West.	1·62	−1·65	9·12	+0·03	8·37	− 1·26	2·90	−0·94	0·20	−0·14
	West Rajputana	0·32	−1·41	4·80	+0·87	6·39	+ 2·53	1·79	+0·26	0·40	+0·33
Madras	East Coast North	3·24	−1·66	6·55	−0·19	9·56	+ 2·38	11·85	+4·95	8·95	+3·20
	Do. Do. A.	5·14	−5·27	12·75	−2·63	13·51	+ 0·76	14·00	+5·37	9·37	+4·61
	Hyderabad South	2·56	−1·77	6·80	+1·67	4·34	− 1·40	7·36	+1·35	3·81	+0·74
	Madras Central	3·17	+0·54	2·27	−0·88	4·68	+ 0·38	10·60	+5·24	2·48	−3·07
	East Coast Central	1·44	−0·21	2·58	+0·13	5·02	+ 1·96	7·90	+4·29	2·42	−7·33
	East Coast South	1·81	−0·46	2·07	−0·93	6·98	+ 1·82	9·57	+4·70	3·82	−4·52
	Madras South	1·50	+0·44	0·64	−0·44	2·81	+ 0·79	4·85	+2·62	3·37	−2·67
	Mean for whole Country.	8·27	−0·56	12·54	−0·73	14·08	+ 2·73	8·27	+0·65	4·19	+0·45

1898. The pre-monsoon meteorological conditions in the Indian land area were favourable for a normal monsoon. The winter snowfall had been much below the normal over the whole of the Western Himalayas and Afghanistan. There was late and unseasonable snowfall over a part of the Western Himalayas, but this melted rapidly and at the end of May the snowfall conditions were normal. The pressure and temperature conditions were favourable for a good monsoon. The conditions in the Indian Seas were satisfactory and favourable, and the only unfavourable feature was the unseasonable snowfall in the Punjab Himalayas which promised to slightly retard the arrival of the Arabian Sea monsoon. There was a slight delay in the establishment of the monsoon current along the West Coast, where it did not set in till about the 10th of June. The Bengal current set in about the normal date and both currents advanced unusually rapidly into Northern India. The general rainfall of the month was about normal, but with some deficiency in North-East India and Burma. Both monsoon currents were fairly steady during July and the general rainfall of the month was about normal. There was more or less deficiency over Burma, North East India and Madras and some excess elsewhere. In August, the Arabian Sea monsoon current was weaker than usual, while the Bay current was of normal strength. As a result, Burma, Assam, Bengal and the North-Western Provinces generally received excessive to very excessive rain, while the Punjab and North-West India generally, as well as the Peninsula received deficient rainfall. In September there was no change in the monsoon currents, the Bombay current remaining weaker than usual, while the Bay current

was of about the normal strength. The chief features in the rainfall distribution of the month were excessive rain in Bihar, general rain in the Deccan and Southern India and scanty rain in North-Western and Central India. The following is a tabular statement of the rainfall of the months June to October 1898:—

Province.	Division.	Rainfall.									
		June.		July.		August.		September.		October.	
		Actual, 1898.	Variation from normal.	Actual, 1898.	Variation from normal.	Actual, 1898.	Variation from normal.	Actual, 1898.	Variation from normal.	Actual, 1898.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Burma	Tenasserim	33·38	— 6·44	37·42	— 9·76	63·59	+ 25·48	26·80	+ 2·11	5·47	— 5·41
	Lower Burma Deltaic	21·38	+ 2·35	22·90	— 0·19	26·36	+ 5·63	15·93	+ 2·15	4·77	— 4·24
	Central Burma	10·88	— 1·70	14·64	+ 1·28	12·61	— 0·83	8·92	+ 0·28	2·36	— 3·81
	Upper Burma	5·46	— 5·22	5·31	— 4·42	9·43	— 1·35	7·26	— 1·59	5·05	+ 0·11
	Arakan	41·65	— 11·49	51·61	+ 3·26	56·05	+ 23·15	23·99	+ 3·19	6·85	— 2·85
Bengal and Assam.	Eastern Bengal	18·99	+ 1·95	16·58	— 1·44	26·25	+ 10·15	11·70	+ 0·68	9·01	+ 3·39
	Assam Surma	19·46	— 3·80	14·47	— 4·53	24·77	+ 4·04	16·65	+ 0·19	5·82	— 0·04
	Do. Hills	27·55	— 5·33	18·63	— 6·30	26·79	+ 3·84	17·83	— 2·84	10·89	+ 3·07
	Do. Brahmaputra	14·87	— 0·95	16·86	+ 0·83	14·79	+ 0·52	11·09	— 0·04	6·71	+ 2·75
	Deltaic Bengal	10·10	— 0·56	11·85	+ 0·04	16·59	+ 4·40	8·09	— 0·41	6·97	+ 2·46
	Central do.	11·92	+ 1·93	8·70	— 3·60	16·07	+ 4·76	15·36	+ 6·12	4·93	+ 1·42
	North do.	21·85	+ 0·71	16·53	— 3·15	13·24	— 3·54	24·14	+ 8·76	3·89	— 0·65
	Bengal Hills	16·29	— 10·93	37·78	+ 2·31	22·71	— 5·27	30·09	+ 10·56	2·78	— 4·41
	Orissa	6·97	— 2·23	9·91	— 1·76	15·29	+ 3·31	8·75	— 3·95	9·14	+ 3·29
	Chota Nagpur	11·35	+ 3·01	14·56	+ 0·41	14·75	+ 0·88	9·84	+ 1·63	2·02	— 0·90
	South Bihar	4·14	— 2·00	13·62	+ 1·33	17·28	+ 5·47	14·77	+ 7·81	1·12	— 1·50
	North do.	6·63	— 2·22	11·31	— 2·29	10·68	— 1·92	24·48	+ 15·21	0·95	— 1·99
North-Western Provinces and Oudh.	North-Western Provinces East.	4·40	+ 0·11	17·01	+ 5·18	17·66	+ 6·87	8·78	+ 1·89	0·06	— 2·12
	South Oudh	5·26	+ 0·87	11·91	+ 1·16	19·14	+ 8·67	4·74	— 1·78	0·45	— 1·15
	North do.	4·97	+ 0·04	15·12	+ 3·43	19·75	+ 9·31	7·79	+ 0·57	0·11	— 1·50
	North-Western Provinces Central.	4·78	+ 1·25	11·23	— 0·72	17·80	+ 7·26	5·75	+ 0·25	0·23	— 0·81
	North-Western Provinces West.	1·13	— 1·22	5·68	— 3·17	9·12	+ 1·42	4·49	— 0·13	0	— 0·54
	North-Western Provinces East Submontane.	7·19	+ 1·26	14·02	+ 1·52	17·60	+ 6·82	14·10	+ 6·19	0·16	— 2·71
	North-Western Provinces West Submontane.	5·26	+ 0·10	13·41	— 1·26	15·89	+ 2·78	7·20	— 0·10	0·08	— 0·75
	North-Western Provinces Hills.	10·17	+ 2·64	18·90	+ 1·87	24·83	+ 8·23	8·18	+ 0·18	0·55	— 0·96
Punjab	South-East Punjab	2·33	— 0·19	5·87	— 1·85	3·62	— 2·34	1·46	— 2·74	0	— 0·36
	South Punjab	1·58	— 0·04	6·52	+ 1·65	0·53	— 3·60	0·97	— 1·41	0	— 0·21
	Central Punjab	0·92	— 0·66	8·42	+ 3·43	1·53	— 3·22	1·24	— 1·09	0	— 0·35
	Punjab Submontane	2·48	— 0·30	11·75	+ 2·53	4·68	— 3·62	3·63	— 0·12	0	— 0·38
	Punjab Hills.	6·49	+ 1·71	14·64	— 2·04	17·62	+ 0·95	3·70	— 2·70	0·06	— 0·84
	North Punjab	0·96	+ 0·07	6·96	+ 2·79	2·82	— 1·96	3·40	+ 1·46	0	— 0·48
	West do.	0·72	+ 0·05	3·68	+ 1·11	0·11	— 1·96	0·93	+ 0·09	0	— 0·10

Province.	Division.	RAINFALL.									
		June.		July.		August.		September.		October.	
		Actual, 1898.	Variation from normal.	Actual, 1898.	Variation from normal.	Actual, 1898.	Variation from normal.	Actual, 1898.	Variation from normal.	Actual, 1898.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Bombay and Malabar Coast Districts (Madras).	Malabar	36·27	— 1·03	35·29	+ 3·86	10·77	— 9·36	13·34	+ 3·16	12·01	+ 1·97
	Travancore	20·44		13·99		3·49		6·24		13·84	
	Madras South Central	1·01	— 1·02	0·85	— 1·51	2·80	— 0·69	8·46	+ 4·14	6·49	+ 0·57
	Coorg	20·18		22·77		9·49		11·35		8·58	
	Mysore	4·70	+ 0·30	5·72	— 0·68	3·81	— 1·23	10·09	+ 5·26	5·56	+ 0·04
	Konkan	31·12	+ 3·98	46·82	+ 6·76	17·70	— 6·26	20·42	+ 5·46	3·35	— 2·17
	Bombay Deccan	7·11	+ 1·31	9·44	+ 0·63	3·64	— 2·50	8·35	+ 3·02	4·09	— 0·91
	Hyderabad North	3·37	— 2·40	12·33	+ 3·87	3·30	— 4·50	7·57	+ 0·02	0·72	— 2·03
	Khandesh	4·37	— 1·32	9·79	+ 2·12	5·33	— 0·66	8·15	+ 1·08	0·21	— 3·40
Central Provinces and Berar.	Berar	5·74	— 1·43	10·03	— 1·50	4·29	— 4·60	5·97	— 1·37	0·28	— 2·21
	Central Provinces West.	6·96	— 0·53	14·71	+ 0·90	12·65	+ 2·78	5·65	— 3·15	0·13	— 1·95
	Central Provinces Central.	8·19	+ 0·68	21·23	+ 3·26	15·25	+ 2·39	6·98	— 0·97	0·30	— 1·55
	Central Provinces East.	6·67	— 1·61	17·46	+ 1·30	12·83	+ 0·29	6·32	— 1·25	1·44	— 0·62
Bombay (North).	Gujarat	9·29	+ 3·02	19·63	+ 1·17	6·01	— 3·27	7·55	— 0·45	0	— 1·26
	Kathiawar	3·77	+ 0·51	10·53	— 0·77	3·10	— 3·18	4·79	+ 0·09	0	— 0·69
	Sind	0·01	— 0·17	4·58	+ 2·72	0·01	— 1·93	0·24	— 0·25	0	— 0·03
	Baluchistan Hills	0·01	— 0·45	1·49	+ 0·37	0	— 0·75	0·08	— 0·18	0	— 0·10
Rajputana and Central India.	Central India East	4·54	— 1·98	12·03	— 0·50	13·65	+ 1·41	5·49	— 1·63	0·02	— 1·55
	Rajputana East, and Central India West.	2·00	— 1·27	8·29	— 0·80	4·22	— 5·43	2·76	— 1·68	0	— 0·34
	West Rajputana	0·37	— 1·36	4·55	+ 0·63	0·29	— 3·58	1·83	+ 0·20	0	— 0·07
Madras	East Coast North	6·17	+ 1·26	9·51	+ 2·73	4·15	— 2·35	5·96	— 0·93	6·36	+ 0·60
	Do. do. A.	9·30	— 1·11	12·25	— 3·12	9·16	— 3·69	11·27	+ 2·64	3·65	— 1·11
	Hyderabad South	4·27	— 0·06	9·93	+ 4·29	3·44	— 2·68	7·04	+ 1·03	1·22	— 1·85
	Madras Central	1·30	— 0·73	2·43	— 0·72	1·93	— 2·37	7·84	+ 2·48	1·82	— 3·73
	East Coast Central	1·89	+ 0·24	1·67	— 0·38	1·60	— 1·46	5·35	+ 1·74	10·45	+ 0·70
	Do. South	1·43	— 0·84	3·19	— 0·81	5·17	+ 0·01	7·07	+ 3·07	10·19	+ 1·85
	Madras South	0·77	— 0·29	0·55	— 0·53	0·99	— 1·03	4·56	+ 2·33	10·02	+ 3·96
	Mean for whole country	5·03	— 0·59	13·36	+ 0·33	11·68	+ 1·10	5·93	+ 1·32	3·27	— 0·67

1899. The meteorological conditions of India antecedent to the establishment of the south-west monsoon were favourable to a normal monsoon and also to its rapid extension over nearly the whole of India. The pressure conditions over India were favourable, the chief fairly persistent features having been a general deficiency of pressure, a local deficiency in Northern India and Burma—most marked in Bengal and the Punjab—and a local excess in the Peninsula and the central parts of the country. The snowfall of the preceding winter had been much less than usual over the whole of the Western Himalayas but had been probably heavier than usual in Kashmir, Kumaun and Garhwal. There was probably

no abnormal accumulation at the end of May. The conditions in the Indian Seas and the Indian Ocean were so far as could be ascertained, satisfactory and favourable, and the air movement in the South-East Trades region was at least normal or somewhat stronger than usual.

The permanent advance of the monsoon current occurred on the Malabar Coast on the 5th June, on the Konkan Coast on the 11th June and in Bengal on the 13th June. The monsoon was fairly strong in June and the rainfall of the month in excess over a large part of the country, the only areas in which the rains were conspicuously deficient at the end of the month being Berar, the Central Provinces and portions of Madras.

In July there was a general excess of rain over the area which usually receives rain during this month from the Bay current and general deficiency over the area dependent on the Arabian Sea or Bombay current. The deficiency was greatest in the north-western and central districts of the Bombay monsoon area, including Kathiawar, Gujarat, Khandesh, Berar, Rajputana, the Deccan and the Konkan. In August the chief features of the rainfall distribution were similar to those of July and the deficiency was again most marked in the north-western and central districts of the area dependent on the Bombay current for its rainfall. During September and October there was no change and the drought over the greater part of India was as severe as during the earlier months of the monsoon. The rainfall of the period June to October was in slight to considerable excess in Assam, Bengal and the east of the North-Western Provinces; it was in slight defect over West Bengal, and was more or less considerably below the normal over the remainder of India. The deficiency was largest and most pronounced in West Rajputana, Sind and Kathiawar in which it exceeded 78 per cent. The following gives a summary of the rainfall variation data for the monsoon months June to October 1899:—

Province.	Division.	Rainfall.									
		June.		July.		August.		September.		October.	
		Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Burma	Tenasserim	29·35	— 10·59	51·19	+ 3·93	34·09	— 3·72	19·97	— 4·01	3·80	— 6·93
	Lower Burma Deltaic	17·52	— 1·66	19·99	— 3·07	20·29	— 0·46	16·18	+ 2·66	3·19	— 5·65
	Central Burma	9·14	— 2·99	17·21	+ 4·75	12·19	— 1·34	8·27	— 0·48	3·01	— 3·12
	Upper do.	6·40	— 3·77	8·36	— 1·65	6·89	— 4·71	8·33	+ 1·13	5·16	+ 0·51
	Arakan	40·70	— 12·30	68·21	+ 19·89	37·66	+ 5·21	18·75	— 1·69	7·00	— 2·43
Bengal and Assam.	Eastern Bengal	17·49	+ 0·45	22·93	+ 4·92	19·46	+ 3·19	12·74	+ 1·72	11·95	+ 6·24
	Assam Surma	31·06	+ 7·77	25·13	+ 6·03	17·20	— 3·77	17·49	+ 1·00	6·82	+ 1·04
	Do. Hills	30·63	— 2·26	21·76	— 3·17	24·35	+ 1·40	22·89	+ 2·22	11·31	+ 3·49
	Do. Brahmaputra	19·88	+ 4·06	17·52	+ 1·88	16·51	+ 2·24	12·38	+ 1·25	6·07	+ 2·11
	Deltaic Bengal	13·91	+ 3·25	19·82	+ 8·01	10·99	— 1·20	8·41	— 0·09	4·41	— 0·10
	Central do.	12·33	+ 2·30	19·00	+ 6·65	11·25	— 0·17	9·36	+ 0·12	2·67	— 0·89
	North do.	24·52	+ 3·39	20·98	— 0·92	22·11	+ 5·04	19·66	+ 4·28	2·52	— 2·68
	Bengal Hills	24·86	— 2·36	31·66	— 3·81	28·06	+ 0·08	23·35	+ 3·82	5·37	— 1·82

Province.	Division.	RAINFALL.									
		June.		July.		August.		September.		October.	
		Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Bengal and Assam.	Orissa	8·61	— 0·59	11·74	+ 0·07	9·55	— 2·04	5·38	— 7·32	8·84	+ 2·99
	Chota Nagpur	11·80	+ 3·56	15·37	+ 1·22	8·67	— 5·19	3·65	— 4·56	0·83	— 2·07
	South Bihar	11·66	+ 5·48	22·20	+ 9·91	11·72	— 0·09	5·37	— 1·59	0·80	— 1·80
	North do.	10·12	+ 1·46	22·37	+ 8·61	19·83	+ 7·52	10·76	+ 1·49	1·05	— 1·74
North-Western Provinces and Oudh.	North-Western Provinces East.	11·61	+ 7·28	18·67	+ 6·84	10·42	— 0·37	2·47	— 4·47	0·30	— 1·88
	South Oudh	7·90	+ 3·51	18·28	+ 7·53	7·89	— 2·59	3·08	— 3·44	0·05	— 1·55
	North do.	8·94	+ 4·01	17·73	+ 6·03	10·49	+ 0·05	2·23	— 4·99	0·26	— 1·35
	North-Western Provinces Central.	11·25	+ 7·72	14·18	+ 2·39	4·87	— 5·68	2·27	— 3·23	0	— 1·04
	North-Western Provinces West.	9·89	+ 7·34	7·26	— 1·59	0·59	— 7·11	0·19	— 4·43	0·01	— 0·53
	North-Western Provinces, East Submontane.	9·77	+ 4·23	26·59	+ 14·19	14·94	+ 4·16	3·12	— 4·79	1·01	— 1·86
	North-Western Provinces, West Submontane.	10·18	+ 5·02	14·63	— 0·04	3·69	— 9·42	0·76	— 6·54	0·22	— 0·61
	North-Western Provinces, Hills.	11·71	+ 4·18	21·42	+ 4·37	9·07	— 7·53	1·59	— 6·41	0·03	— 1·48
Punjab	South-East Punjab	5·40	+ 2·83	3·25	— 4·47	0·88	— 5·08	0·33	— 3·87	0·05	— 0·31
	South do.	2·44	+ 0·82	1·56	— 3·23	1·09	— 3·13	0·25	— 2·13	0·06	— 0·15
	Central do.	1·83	+ 0·27	2·74	— 2·25	1·57	— 3·18	0·10	— 2·23	0·04	— 0·31
	Punjab Submontane	3·89	+ 1·03	5·35	— 4·07	2·51	— 5·90	0·30	— 3·59	0·14	— 0·24
	Punjab Hills	6·50	+ 1·80	15·25	— 1·44	7·45	— 9·13	0·38	— 5·85	0·46	— 0·46
	North Punjab	1·96	+ 1·07	3·63	— 0·54	2·59	— 2·19	0·81	— 1·13	0·29	— 0·19
	West do.	1·09	+ 0·42	0·78	— 1·79	0·62	— 1·45	0·06	— 0·78	0·02	— 0·08
Bombay and Malabar Coast Districts (Madras).	Malabar	38·80	+ 2·40	15·74	— 19·89	10·34	— 10·41	7·20	— 3·24	18·30	+ 0·34
	Travancore	17·31		7·91		3·58		3·58		16·79	
	Madras South Central.	0·56	— 1·44	0·84	— 1·46	1·25	— 2·16	7·41	+ 3·09	4·46	— 1·43
	Coorg	25·33		10·41		9·75		8·91		5·52	
	Mysore	5·06	+ 0·88	1·81	— 4·51	2·06	— 2·98	8·39	+ 3·77	3·35	— 2·17
	Konkan	26·04	— 1·10	9·63	— 39·41	10·20	— 13·76	5·57	— 9·39	1·65	— 3·87
	Bombay Deccan	5·12	— 0·63	2·22	— 7·07	1·55	— 4·59	6·87	+ 1·34	0·98	— 4·02
	Hyderabad North	3·91	— 2·15	1·53	— 7·57	5·15	— 2·85	3·81	— 3·74	0·04	— 2·71
	Khandesh	5·81	+ 0·12	2·06	— 5·61	1·82	— 4·17	2·15	— 4·82	0·10	— 3·58
Central Provinces and Berar.	Berar	4·33	— 2·84	2·35	— 9·24	2·44	— 6·45	1·61	— 5·73	0·02	— 2·47
	Central Provinces West.	4·74	— 2·75	5·43	— 8·38	4·25	— 5·62	2·08	— 6·72	0·02	— 2·06
	Central Provinces Central.	5·27	— 2·95	9·09	— 8·93	7·79	— 5·07	2·34	— 5·61	0	— 1·85
	Central Provinces East.	7·04	— 1·27	9·91	— 6·16	14·16	+ 1·02	2·40	— 5·17	0·04	— 2·02
Bombay (North).	Gujrat	8·77	+ 2·51	0·96	— 17·50	0·66	— 8·32	1·13	— 6·30	0·03	— 1·33
	Kathiawar	3·67	+ 0·41	0·54	— 10·73	0·34	— 5·94	0·84	— 3·86	0·01	— 0·68
	Sind	0·03	— 0·17	0	— 1·86	0·01	— 1·03	0	— 0·48	0	— 0·03
	Baluchistan Hills	0·06	— 0·39	0·09	— 0·93	0·26	— 0·50	0·01	— 0·14	0·03	— 0·07

Province.	Division.	RAINFALL.									
		June.		July.		August.		September.		October.	
		Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.	Actual, 1899.	Variation from normal.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Rajputana and Central India.	Central India East	13·91	+ 7·39	7·77	— 5·76	2·91	— 9·37	1·79	— 5·28	0	— 1·55
	Rajputana East and Central India West.	7·40	+ 4·13	5·87	— 3·22	0·28	— 9·37	0·53	— 3·31	0·01	— 0·33
	West Rajputana	1·42	— 0·33	0·56	— 3·37	0·02	— 3·85	0·15	— 1·38	0	— 0·07
Madras	East Coast North	3·22	— 1·70	4·42	— 2·24	6·84	— 0·17	5·73	— 0·97	4·93	— 2·17
	Do. do. A.	4·01	— 6·40	11·15	— 4·23	13·15	+ 0·40	5·97	— 2·66	2·18	— 2·58
	Hyderabad South	3·08	— 1·30	1·77	— 3·97	3·86	— 2·46	5·11	— 0·90	0·16	— 2·91
	Madras Central	0·67	— 1·95	0·50	— 2·71	2·54	— 1·78	8·06	+ 2·68	2·17	— 3·42
	East Coast Central	0·73	— 0·92	0·84	— 1·61	2·51	— 0·55	3·70	+ 0·09	13·08	+ 3·32
	Do. South	0·69	— 1·58	2·08	— 1·07	2·37	— 2·65	5·39	+ 0·89	15·23	+ 6·44
	Madras South	0·36	— 0·70	0·64	— 0·39	0·61	— 1·29	1·55	— 0·56	8·53	+ 2·50
	Mean for whole country	10·26	+ 0·77	11·35	— 1·46	7·90	— 2·85	5·46	— 2·11	2·98	—0·98

Note.—The preceding tabular statements have been copied from the rainfall tables given in the Monthly Weather Reviews of the Indian Meteorological Department. Slight variations are shown in the actual and variation data due to changes in the divisions and in the number of recording stations, but the general results are comparable.

PART II.

LONG PERIOD PRESSURE OSCILLATIONS AND THEIR RELATION TO THE TRADES-MONSOON RAINFALL.

The preceding sections give a brief account and full tabular statement of the rainfall over India for each of the seven monsoon seasons (1893—1899) under discussion. The following gives a tabular statement of the principal features of the rainfall variations of each season derived from the variations of all parts of India, omitting Burma and the hill districts:—

TABLE I.

Years.	May.	June.	July.	August.	September.	October.	Seasonal variation.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1893 . . .	+1·59	+2·51	+0·07	—0·98	+1·27	+0·42	+4·88
1894 . . .	—0·55	+1·14	+1·07	+0·66	+0·94	+2·81	+6·07
1895 . . .	—0·44	+0·09	—0·67	—0·09	—1·27	—0·25	—2·63
1896 . . .	—0·29	+0·28	—0·39	+0·46	—2·98	—2·41	—5·33
1897 . . .	—0·36	—0·73	—0·44	+2·46	+1·16	+0·31	+2·40
1898 . . .	—0·68	—0·19	+0·45	+0·17	+1·32	—0·38	+0·69
1899 . . .	—0·08	+1·49	—2·12	—2·79	—2·32	—0·67	—6·49

The preceding data show, that, during the years under review, there have occurred very large variations in the monsoon rainfall over India. In the year 1894 the rainfall was excessive throughout the whole monsoon season, from June to October, and the seasonal excess was more than 6 inches; while, on the other hand, in the year 1899 the rainfall was short of the normal in each month of the monsoon season, except June, and the total seasonal deficiency was as much as $6\frac{1}{2}$ inches. The striking contrasts which occur in the rainfalls of the different monsoon seasons render the seven years under review particularly favorable for the purposes of the present investigation, the objects of which are to connect, if possible, the meteorological changes in progress over the Arabian Sea and the West Equatorial Belt with the variations of the rainfall over the Trades-monsoon area, and more particularly the monsoon rainfall over India.

The first point which presents itself for investigation is the relation existing between

the mean pressure conditions of the Western Equatorial Belt and the South-East Trades region and the Indian monsoon rainfall:—

SOUTH-EAST TRADES REGION.

Seasonal pressures in the South-East Trades region derived from the records of the Mauritius, Zanzibar and Seychelles observatories.—The following table gives the mean monthly pressures of the South-East Trades region, derived from the barometric means of the three observatories at Mauritius, Zanzibar and the Seychelles:—

TABLE II.

YEAR.	STATION.	May.	June.	July.	August.	September.	October.
		"	"	"	"	"	"
1893	Zanzibar	29·978	30·055	30·058	30·100	30·002	29·946
	Mauritius	30·051	30·106	·157	·225	·140	30·072
	Seychelles*	29·895	29·897	29·925	29·974	29·925	29·911
	Mean	29·975	30·019	30·047	30·100	30·022	29·976
			Mean=30·023				
1894	Zanzibar	29·972	30·052	30·046	30·026	29·998	29·931
	Mauritius	30·016	·103	·116	·139	30·110	30·036
	Seychelles	29·874	29·894	29·898	29·894	29·908	29·886
	Mean	29·954	30·016	30·020	30·020	30·005	29·951
			Mean=29·994				
1895	Zanzibar	29·975	30·064	30·078	30·024	30·033	29·956
	Mauritius	30·050	30·105	30·142	30·113	30·134	30·046
	Seychelles	29·871	29·878	29·938	29·899	29·931	29·877
	Mean	29·965	30·016	30·053	30·012	30·033	29·960
			Mean=30·007				
1896	Zanzibar	29·978	30·026	30·096	30·068	30·018	29·977
	Mauritius	30·039	30·105	30·178	30·204	30·143	30·079
	Seychelles	29·894	29·882	29·959	29·939	29·914	29·916
	Mean	29·970	30·004	30·078	30·070	30·025	29·991
			Mean=30·023				
1897	Zanzibar	29·984	30·066	30·054	30·047	30·021	29·981
	Mauritius	30·049	30·086	30·131	30·151	30·142	30·084
	Seychelles	29·853	29·867	29·884	29·897	29·906	29·924
	Mean	29·962	30·006	30·023	30·032	30·023	29·996
			Mean=30·007				

* Barometric means interpolated.

TABLE II—*concld.*

YEAR.	STATION.	May.	June.	July.	August.	September.	October.
		"	"	"	"	"	"
1898	Zanzibar	29·926	30·021	30·013	30·045	29·989	29·948
	Mauritius	30·007	30·099	30·121	30·128	30·093	30·053
	Seychelles	29·838	29·872	29·891	29·907	29·883	29·895
	Mean	29·924	29·997	30·014	30·027	29·988	29·965
			Mean=29·986				
1899	Zanzibar	29·975	30·064	30·090	30·067	30·067	29·961
	Mauritius	30·030	30·107	30·220	30·209	30·161	30·078
	Seychelles	29·862	29·915	29·944	29·930	29·962	29·918
	Mean	29·956	30·029	30·085	30·069	30·063	29·986
			Mean=30·031				

From the above data the following table has been constructed:—

TABLE III.

YEARS.	1893	1894	1895	1896	1897	1898	1899
	"	"	"	"	"	"	"
Mean pressure South-East Trades Region.	30·023	29 994	30·007	30·023	30·007	29·986	30·031
Variation from normal	+0·013	—·016	—·003	+·013	—·003	—·024	+·021
Abnormal change from season to season.		—·029	+·013	+·016	—·016	—·021	+·045
Rainfall variation over India	+4·88	+6·07	—2·63	—5·33	+2·40	+0·69	—6·49

The above gives (1st) the actual mean pressure of the South-East Trades region as determined from the registers of Mauritius, Zanzibar and the Seychelles observatories for the six months, May to October for each year from 1893 to 1899; (2nd) the variation of each season's mean from the mean of the whole; (3rd) the abnormal pressure change between the season of date and the preceding season; and (4th) the rainfall variation over India (excluding Burma) for the six months May to October for each year. The pressure values apparently exhibit a slight oscillation. Thus in 1893, 1896 and 1899 the mean pressure was at a maximum, while in the intervening years, *viz.*, in 1894 and 1898 it was at a minimum, thus suggesting an oscillation of about three years in the pressure conditions. This is shown by the curve given in Fig. 1, Pl. LXXVI:—

An inspection of the actual mean pressures and of the corresponding rainfall variations over India, as given in Table III shows, that there exists no direct relation between the two phenomena; thus in 1893 and in 1896 the mean pressure of the South-East Trades region for the monsoon period was 30·023" in each case, while the corresponding rainfall variations over India were +4·88 inches and —5·33 inches respectively, showing that the same actual mean pressure in the South-East Trades region may be accompanied with opposite rainfall conditions in India in different years. But an inspection of the above curve exhibits what appears to be a relation, not indeed, between the actual pressure and the corresponding rainfall variation, but between the pressure change between one season and the previous one and the accompanying rainfall variation over India.

Thus in 1893 the pressure movement was downward and the rainfall variation was +4·88 inches; in 1894 the downward movement was maintained, the change between the two seasons amounting to —0·029″, and the abnormal rainfall over India was +6·07 inches. Between 1894 and 1895 the pressure movement was upward and the rainfall variation during the monsoon of 1895 was —2·63 inches. This upward movement was maintained between 1895 and 1896, and the rainfall variation of the 1896 monsoon was —5·33 inches. After 1896 the pressure movement changed and pressure decreased until 1898, the rainfall variations for the monsoon seasons of 1897 and 1898 having been +2·40 inches and +0·69 inches respectively. Between 1898 and 1899 the pressure movement was upward and rapid, and the variation of the monsoon rainfall of 1899 was —6·49 inches.

The preceding data and discussion show that, if a connexion exists between the pressure conditions of the South-East Trades region and the rainfall of the monsoon months in India, that connexion is to be found, not between the actual pressures and the rainfall variations, but between the oscillatory changes of pressure and the rainfall variations. Thus if a south-west monsoon period be included in the upward portion of a pressure oscillation that particular period will be one of deficient rain and *vice versâ*: moreover it would appear that the velocity of the pressure change during the pressure oscillation exercises an important varying influence on the rainfall. It will be noticed that, in the first oscillation (1893 to 1896), the passage of the pressure from the maximum to the minimum was carried out during the first year of the oscillation and that the change amounted to —·029″. This comparatively sudden fall was accompanied with heavier rain in India than was measured in any other season of the series under review. Similarly the recovery in the second oscillation was carried out in one year, the change in this year amounting to +0·045″. This sudden rise was accompanied with a lighter rainfall than has been recorded in any other season. On the other hand, the recovery in the oscillation of the years 1893 to 1896 took two years (1895 and 1896) to carry out, and the rainfall variations of those two monsoon seasons was —2·63 inches and —5·33 inches respectively. The falling portion of the oscillation of the years 1896 to 1899 occupied two years, and the rainfall variations of those two years (1897 and 1898) were +2·40 inches and +0·69 inch respectively. With regard to the latter year it is important to note that though the change between that year and the year immediately preceding it was as much as —0·021″, practically the whole of this change occurred between January and May, and pressure during the monsoon months was exceptionally steady (see plate LXXVII). Hence the preceding figures suggest that pressure oscillations of about three years' duration occurred during this period over the South-East Trades region, and that these oscillations exercised an influence on the Indian rainfall, an influence which was proportional to the rapidity of the changes in the pressure oscillation. Employing the two cases when the changes between the maximum and the minimum of the oscillations were accomplished in one year, the variations of the monsoon rainfall over India were as follows:—

1894		1899
+6·07″	and	—6·49″

While the pressure changes agreeing with these variations were respectively as follows:—

1893 to 1894.		1898 to 1899.
—·029″	and	+·045″

From the above it would appear that there exists no direct agreement between the amount of the barometric change from one season to the next and the actual amount of the rainfall variation over India, but the divergency is probably largely due to the varying conditions under which the rainfall takes place. Thus when conditions are operative tending to increased rainfall the influence is first felt in those regions where normally the rainfall is largest, as for example along the West Coast of the Peninsula, Lower Bengal, etc., so that a large variation is immediately produced, while, on the contrary, when from any cause the monsoon currents take off and the monsoon rainfall diminishes, this diminution first manifests itself over the dry districts of the Peninsula or the dry north-west districts of India where there may be a large relative diminution of rainfall without the total fall of the whole country being much affected thereby. Accepting the preceding relations, however, as approximately correct and taking into account the various conditions under which rain falls in India, the following table would be obtained showing the probable rainfall variation over India when the barometric change between one season and the next over the South-east Trades region was as follows:—

Barometric change.	Rainfall variation.
+·045"	—6·50 inches.
+·030	—5·75
+·015	—5·00
0	0
—·015	+2·40
—·030	+6·00
—·045	+9·60

Monthly pressures in the South-East Trades region derived from the records of the Mauritius, Zanzibar and Seychelles observatories.—The following table gives the mean barometric pressures for each month of the seven monsoon seasons 1893-99, together with the abnormal change from one month to the next and the month's rainfall variation over India:—

TABLE IV.

Years.		May.	June.	July.	August.	September.	October.
1893	Mean pressure	29·975	30·019	30·047	30·100	30·022	29·976
	Variation from normal	+·017	+·007	+·001	+·053	—·001	+·001
	Abnormal change		—·010	—·006	+·052	—·054	+·002
	Rainfall variation		+2·51	+0·07	—0·98	+1·27	+0·42
1894	Mean pressure	29·951	30·016	30·020	30·020	30·005	29·951
	Variation from normal	—·004	+·004	—·026	—·027	—·018	—·024
	Abnormal change		+·008	—·030	—·001	+·009	—·006
	Rainfall variation		+1·14	+1·07	+0·66	+0·94	+2·81

TABLE IV—*concld.*

Years.		May.	June.	July.	August.	September.	October.
1895	Mean pressure	29·965	30·016	30·053	30·012	30·033	29·960
	Variation from normal	+·007	+·004	+·007	—·035	+·010	—·015
	Abnormal change		—·003	+·003	—·042	+·045	—·025
	Rainfall variation		+·009	—0·67	—0·09	—1·27	—0·25
1896	Mean pressure	29·970	30·004	30·078	30·070	30·025	29·991
	Variation from normal	+·012	—·008	+·032	+·023	+·002	+·016
	Abnormal change		—·020	+·040	—·009	—·021	+·014
	Rainfall variation		+·028	—0·39	+0·46	—2·98	—2·41
1897	Mean pressure	29·962	30·006	30·023	30·032	30·023	29·996
	Variation from normal	+·004	—·006	—·023	—·015	0	+·021
	Abnormal change		—·010	—·017	+·008	+·015	+·021
	Rainfall variation		—·073	—0·44	+2·46	+1·16	+0·31
1898	Mean pressure	29·924	29·997	30·014	30·027	29·988	29·965
	Variation from normal	—·034	—·015	—·032	—·020	—·035	—·010
	Abnormal change		+·019	—·017	+·012	—·015	+·025
	Rainfall variation		—·019	+0·45	+0·17	+1·32	—0·38
1899	Mean pressure	29.956	30·029	30·085	30·069	30·063	29·986
	Variation from normal	—·002	+·017	+·039	+·022	+·040	+·011
	Abnormal change		+·019	+·022	—·017	+·018	—·029
	Rainfall variation		+1·49	—2·12	—2·79	—2·32	—0·67

In the preceding paragraphs and tables the actual mean pressures of each monsoon season have been employed for the discussion as they were derived from the means of the whole six months of each year, and were comparable one with the other, but when it is attempted to trace the relation, suggested above, between the monthly abnormal pressure changes in the South-East Trades region and the rainfall variations over India through the different months of each monsoon season, the variation from the normal must be employed instead of the actual values as there is a seasonal change of pressure in progress which would mask the smaller abnormal oscillations. Beginning with May and June 1893 the figures giving the variations of pressure from the normal show that between those months there occurred an abnormal barometric fall amounting to 0·010″ which was accompanied with an abnormal rainfall of +2·51 inches over India; an abnormal fall of pressure of 0·006″ between June and July and an abnormal fall of rain of +0·07 inch over India; and an abnormal rise of 0·052″ of pressure between July and August accompanied with an abnormal fall of rain over India of —0·98 inch. Continuing this comparison throughout the whole of the months of the seven monsoon seasons and arranging the figures in two groups and in two columns in each, one representing the abnormal

monthly barometric change and the other the rainfall variations, the following data are obtained :—

Abnormal downward movements of pressure.		Abnormal upward movements of pressure.	
Monthly pressure change South-East Trades. Inch.	Rainfall variation over India. Inches.	Monthly pressure change South-East Trades. Inch.	Rainfall variation over India. Inches.
—·010	+2·51	+·052	—0·98
—·006	+0·07	+·002	+0·42
—·054	+1·27	+·008	+1·14
—·030	+1·07	+·009	+0·94
—·001	+0·66	+·003	—0·67
—·006	+2·81	+·045	—1·27
—·003	+0·09	+·040	—0·39
—·042	—0·09	+·014	—2·41
—·025	—0·25	+·008	+2·46
—·020	+0·28	+·015	+1·16
—·009	+0·46	+·021	+0·31
—·021	—2·98	+·019	—0·19
—·010	—0·73	+·012	+0·17
—·017	—0·44	+·025	—0·38
—·017	+0·45	+·019	+1·49
—·015	+1·32	+·022	—2·12
—·017	—2·79	+·018	—2·32
—·029	—0·67		

The above shows that out of 18 occasions on which the barometer in the South-East Trades region exhibited an abnormal fall between one month and the next there were 11 occasions on which the corresponding rainfall over India was heavier than usual and 7 on which it was lighter, while out of the 17 occasions on which the barometer exhibited an abnormal rise there were 9 on which less rain than usual followed. The above shows that an abnormal fall of the barometer over the South-East Trades region between one month and the next will probably (as 3 : 2) be accompanied with an abnormally heavy fall of rain over India, while it is about an even chance that an abnormal rise will be followed by more or less rain. This is largely due to the peculiar circumstances under which rain falls over India to which attention has been drawn above. The conclusion to be derived from the above is, that while the larger pressure changes which form portions of general pressure oscillations exercise an important influence on the Indian weather, the minor pressure changes occurring from month to month in the South-East Trades region are only faintly reproduced in the rainfall variations over India. The following summarises the important pressure changes and the accompanying rainfall variations :—

TABLE V.

Pressure change over South-East Trades region.		Rainfall variation over India.	
		Inches.	
Between 1893 and 1894 . .	—·029	+6·07	in the monsoon of 1894
„ 1894 and 1895 . .	+·013	—2·63	„ „ 1895.
„ 1895 and 1896 . .	+·016	—5·33	„ „ 1896.
„ 1896 and 1897 . .	—·016	+2·40	„ „ 1897.
„ 1897 and 1898 . .	—·021	+0·69	„ „ 1898
„ 1898 and 1899 . .	+·045	—6·49	„ „ 1899

It has been attempted to show above that the primary and most important influence in connexion with the monsoon rainfall variations over India during the period under discussion was the pressure oscillation, and it is necessary to investigate the area over which these oscillations are produced. With this object the observations made on board ships traversing the Equatorial Belt Lat. 12° S. to Lat. 4° N. have been collected under the months and seasons in which they were recorded and the results are given below.

Monthly pressures in the Equatorial Belt derived from the records of ships' observations.—The following table gives the mean monthly barometric pressure of the Equatorial Belt for the seven monsoon seasons from 1893 to 1899:—

TABLE VI.

MEAN 8 A.M. PRESSURE OF THE EQUATORIAL REGION BETWEEN LATS. 4° N. AND 12° S. AND LONGS. 40° AND 80° E.

YEAR.	MEAN 8 A.M. PRESSURE OF						
	May.	June.	July.	August.	September.	October.	Season.
	"	"	"	"	"	"	"
1893	29·956	29·922	29·947	29·986	29·966	29·943	29·953
1894	·907	·932	·952	·952	·962	·959	·944
1895	·927	·912	·963	·919	·961	·919	·933
1896	·934	·928	·983	·942	·938	·937	·944
1897	·894	·905	·919	·930	·921	·956	·921
1898	·891	·910	·910	·932	·913	·927	·914
1899	·891	·928	·969	·946	30·003	·937	·946
Mean .	29·914	29·920	29·949	29·944	29·952	29·939	29·936

Following the plan adopted in discussing the returns of the three land observatories the following table of mean seasonal pressures has been constructed. The table gives the mean pressure over the sea area bounded on the west by the African coast; on the east by Long. 80°E.; on the south by Lat. 12°S.; and on the north by Lat. 4°N. for the seasons (May to October) for each year from 1893-1899:—

TABLE VII.

YEAR.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
	"	"	"	"	"	"	"
Mean barometric pressure . .	29·953	29·944	29·933	29·944	29·921	29·914	29·946
Variation from normal . . .	+·017	+·008	—·003	+·008	—·015	—·022	+·010
Abnormal change from season to season.	...	—·009	—·011	+·011	—·023	—·007	+·032
Rainfall variation over India . .	+4·88	+6·07	—2·63	—5·33	+2·40	+0·69	—6·49

Comparing the above data with the pressure conditions as determined from the observations recorded at the stations of Mauritius, Zanzibar and the Seychelles (Table III) it will be noticed that there exist certain small differences between the two records. Thus the highest mean pressure of the period was reported in the year 1893 in the ships' series of observations instead of in 1899 as in the land observatory series. The year with the lowest mean pressure was 1898 in both series. Figure II, Plate LXXVI, gives the pressure curve of the Equatorial Belt derived from the ships' barometric observations for comparison with the pressure curve derived from the observations of the three land observatories.

Comparing the above curve with the curve given by the observatories in the South-East Trades region it will be noticed that the amplitude of the first oscillation is much smaller in this series than in that of the fixed observatories, and secondly that the minimum of the first oscillation occurred in 1895 in the curve derived from the ships' observations and in 1894 in the curve derived from the fixed observatories' records. The second oscillation is alike in its mean features in the two series, but the amplitude of the second oscillation is again greater in the case of the first than in the case of the second series of observations. As the observations refer, to a great extent at least, to the same area these differences are somewhat remarkable, and the explanation probably lies in the inclusion of the observations of the Mauritius Observatory in the first series. This observatory lies in Lat. 20°S. and is consequently 8° of latitude to the southward of the southerly limits of the area dealt with in the second series. The Figs. 3, 4 and 5, Plate LXXVI, give the curves and represent the course of pressure for the three land observatories at Mauritius, Zanzibar and the Seychelles separately for the seven monsoon seasons.

The amplitudes of the oscillation in the case of the 1893-96 oscillation were ·038" in the case of Mauritius, ·023" in the case of Zanzibar and ·029" in the case of the Seychelles, while in the case of the second oscillation the amplitudes were:— ·044" in the case of Mauritius, ·044" in the case of Zanzibar and ·041" in the case of the Seychelles; hence it is justifiable to conclude that the actions which produced the first oscillation were much more strongly operative in Lat. 20°S. than within the Equatorial Belt, while, on the contrary, the causes producing the second oscillation were practically as strongly marked in Lat. 5°S. as in Lat. 20°S.

The general conclusions as determined from the first series of observations have not, however, been modified by the second series. In 1894 and 1896 the actual mean pressures of the monsoon seasons derived from the ships' observations were identical, and in 1899 practically identical, while the rainfall variations over India during those monsoon seasons were:—in 1894 +6·07 inches, in 1896 —5·33 inches and in 1899 —6·49 inches. Hence the actual mean height of the barometer in Equatorial regions was unimportant in respect to the rainfall variations. On the other hand, pressure fell during 1893 and 1894, and the rainfall over India was heavier than usual during those two monsoon seasons. In 1895 the barometer was still falling, but the rainfall was less than the average during that year's monsoon. Between the seasons of 1895 and 1896 the barometer rose and the rainfall variation was —5·33 inches. Between 1896 and 1898 pressure diminished in the Equatorial Belt and the Indian monsoon rainfall variations were +2·40 inches and +0·69 inch respectively, while between the seasons of 1898 and 1899 pressure increased in the Equatorial Belt as much as 0·032" and the rainfall variation over India was the largest on record, *viz.*, —6·49 inches. These results are in general agreement with those obtained

from the observations of the three land observatories of the South-East Trades region, and it is hardly necessary to work through the records month by month as was done with the means of the first series. The net result is to confirm the conclusions derived from the investigation of the pressure observations of the three land observatories and to support the suggestion that the actual height of the barometer in Equatorial regions is unimportant for forecasting purposes, while the position of the season in the rising or falling portion of the pressure oscillation in progress at the time is the important factor in determining the rainfall of the monsoon season, because a south-west monsoon period, which is included in a rising portion of a pressure oscillation, will receive less rain than usual and *vice versâ*, the amount of the variation of the rainfall being in general accord with the velocity of the changes in the pressure oscillation.

This relation between the pressure oscillations and the Indian monsoon rainfall has now been traced from Lat. 20° S. as far north as Lat. 4° N., and the investigation can now be carried into the Arabian Sea.

Arabian Sea.

The following table gives the mean monthly barometric pressures of the Arabian Sea for each month of the seven monsoon seasons and for the whole of each monsoon season from 1893 to 1899 derived from the observations taken on board vessels traversing that area :—

Table VIII.

Years.	Mean 8 A.M. pressure of the whole Arabian Sea from 4°N. to 24°N. for 1893-1899.						
	May.	June.	July.	August.	September.	October.	Season.
1893 . . .	29·797	29·673	29·700	29·763	29·803	29·910	29·774
1894 . . .	·787	·670	·672	·711	·802	·867	·751
1895 . . .	·833	·682	·724	·710	·838	·849	·773
1896 . . .	·833	·672	·722	·755	·821	·920	·787
1897 . . .	·811	·724	·677	·716	·795	·915	·773
1898 . . .	·788	·688	·668	·754	·788	·865	·759
1899 . . .	·796	·721	·757	·779	·884	·912	·808
Mean .	29·806	29·690	29·703	29·741	29·819	29·891	·775

Collecting the above data into seasons (May to October) as was done with the two preceding series of observations the following table has been obtained :—

Table IX.

Years.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
Mean barometric pressure .	29·774	29·751	29·773	29·787	29·773	29·759	29·808
Variation from normal . .	—·001	—·024	—·002	+·012	—·002	—·016	+·033
Abnormal change from season to season.	...	—·023	+·022	+·014	—·014	—·014	+·049
Variation of Indian rainfall .	+4·88	+6·07	—2·63	—5·33	+2·40	+0·69	—6·49

A comparison of the above table with the tables of mean seasonal pressures for the South-East Trades region and for the Equatorial Belt given on pages 431 and 436 shows that the general course of the pressure curve is the same over the Arabian Sea as over the other two regions. The two pressure oscillations are distinctly marked, the first running from 1893 to 1896 with its minimum in 1894, the second running from 1896 to 1899 with its minimum in 1898. This is shown in Fig. 6, Plate LXXVI.

It will be noticed that the course of the above pressure curve agrees more distinctly with the curve derived from the records of the three land observatories in the South-East Trades region than with the pressure curve derived from the ships' observations in the Equatorial Belt. The following gives the amplitudes of the two oscillations in the three cases:—

TABLE X.

South-East Trades Region.		Equatorial Belt.		Arabian Sea.	
First oscillation.	Second oscillation.	First oscillation.	Second oscillation.	First oscillation.	Second oscillation.
·029″	·045″	·024″	·030″	·036″	·049″

The above shows a close agreement between the amplitudes of the first and second oscillations in the first and third columns. In both cases the amplitude of the second oscillation was greater than that of the first and in both cases the amplitude was greater in the northern than in the southern region. Hence it would appear that the actions occasioning these two oscillations were more strongly marked over the Arabian Sea than over the Equatorial Belt, but, if the observations at Mauritius, Zanzibar and the Seychelles and of the ships of the Equatorial Belt be all accepted as correct, it would appear that the actions giving rise to both these oscillations were as strongly marked over the south of the South-East Trades region as over the Arabian Sea, while they were feebly marked over the purely Equatorial Zone. The following gives in tabular form the amplitudes of the two oscillations as shown in these different regions:—

TABLE XI.

	South-East Trades Region.			Equatorial Belt.	Arabian Sea.
	Mauritius Lat. 20° S.	Zanzibar Lat. 11° S.	Seychelles Lat. 5° S.		
	″	″	″	″	″
First oscillation . .	·038	·023	·029	·024	·036
Second oscillation . .	·044	·045	·041	·030	·049

The above data appear to show that the actions determining these oscillations are less felt over Equatorial regions than in the higher latitudes about the Tropics, so that just as the abnormal pressure changes become larger on receding from the Equator so the pressure oscillations are also more strongly marked and generally greater in higher latitudes than near the Equator.

Referring again to the table on page 438 it will be observed that the relation between the abnormal changes of pressure from one monsoon season to the next and the Indian rainfall is similar to that pointed out when discussing the pressure curves of the South-East Trades region and of the Equatorial Belt. Thus between 1893 and 1894 there occurred a marked fall of the barometer which was accompanied with heavier rain than usual over India; between 1894 and 1896 pressure exhibited an abnormal rise and the Indian rainfall was less than usual; between 1896 and 1898 the barometer fell again and rain in India exceeded the average; while between 1898 and 1899 pressure underwent a rapid recovery and the rainfall over India was phenomenally light.

INDIA.

The pressure variations over India show that the pressure over that country passes through the same oscillations as does the pressure over the adjacent sea areas. This is shown below:—

TABLE XII.

YEARS.	VARIATION OF THE MEAN 8 A.M. PRESSURE OF INDIA FROM THE NORMAL FOR EACH MONTH OF THE MONSOON SEASONS.						
	May.	June.	July.	August.	September.	October.	Season.
	b	*b*	*b*	*b*	*b*	*b*	*b*
1893 . . .	—·011	+·016	+·015	+·011	—·022	—·011	0
1894 . . .	—·023	—·022	+·006	—·022	—·018	—·033	—·018
1895 . . .	—·007	+·019	+·022	—·013	+·017	+·002	+·007
1896 . . .	+·013	—·016	—·010	+·005	+·021	+·040	+·009
1897 . . .	—·005	—·011	0	—·015	—·024	—·016	—·011
1898 . . .	—·009	—·025	—·018	—·020	+·002	—·006	—·012
1899 . . .	—·019	+·009	+·006	0	+·038	+·034	+·012

The preceding table gives the pressure variation of the whole of India for each month of the seven monsoon seasons and the variation of each season. Collecting the above data under the seasons as was done with the preceding series of observations the following table has been obtained:—

TABLE XIII.

YEARS.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
	b	*b*	*b*	*b*	*b*	*b*	*b*
Pressure variation	0	—·018	+·007	+·009	—·011	—·012	+·012
Abnormal change from season to season.	0	—·018	+·025	+·002	—·020	—·001	+·024
Variation of Indian rainfall . . .	+4·88	+6·07	—2·63	—5·33	+2·40	+0·69	—6·49

From the preceding table the curve given in Fig. 7, Plate LXXVI, has been drawn.

The preceding data and curve show that the two pressure oscillations are distinctly marked, the first running from 1893 to 1896 with its minimum in 1894 and the second running from 1896 to 1899 with its minimum in 1898. The relation of these pressure oscillations to the Indian rainfall has already been pointed out by Mr. Eliot in a memoir published in Vol. VI of the Indian Meteorological Memoirs and the fact is only referred to here to show that these oscillations were general throughout the whole Trades-Monsoon area during the period under discussion.

The march of Pressure at the elevation of the Hill stations.—The following table gives the mean monthly barometric pressure at Newera Eliya (elevation 6,240 feet):—

TABLE XIV.

Years.	May.	June.	July.	August.	September.	October.	Mean of period, May to October.
	"	"	"	"	"	"	"
1893 . . .	24·031	24·005	23·998	24·029	24·014	24·039	24·024
1894 . . .	·025	·005	24·017	23·991	·015	·035	·015
1895 . . .	·091	·055	·069	24·049	·073	·074	·069
1896 . . .	·105	·051	·087	·080	·096	·118	·090
1897 . . .	·067	·065	·055	·050	·061	·100	·066
1898 . . .	·060	·038	·026	·056	·078	·064	·054
1899 . . .	·056	·084	·093	·093	·113	·101	·096
Mean .	24·067	24·043	24·053	24·050	24·069	24·076	24·059

Following the plan adopted in discussing the pressure returns in the earlier sections the following table has been constructed showing the mean pressure at Newera Eliya for each monsoon season from 1893 to 1899:—

TABLE XV.

Years.	1893	1894	1895	1896	1897.	1898.	1899.
	"	"	"	"	"	"	"
Mean pressure, Newera Eliya .	24·024	24·015	24·069	24·090	24·066	24·054	24·096
Departure from normal . . .	—·035	—·044	+·010	+·031	+·007	—·005	+·037
Abnormal change from season to season.	...	—·009	+·054	—·021	—·024	—·012	+·042

Comparing the preceding data with the seasonal data for the Arabian Sea it will be observed that the march of pressure at the elevation of 7,000 feet is similar to that at the level of the sea. This is shown in the curve given in Fig. 8, Plate LXXVI.

It will be seen that the two pressure oscillations are distinctly marked, the first running from 1893 to 1896 with its minimum in 1894, the second running from 1896 to 1899 with its minimum in 1898. The amplitude of the first oscillation was ·075″ and that of the second ·042″, so that the amplitudes at the elevation of 7,000 feet were at least as large, if not larger, than at sea-level.

The following gives the mean monthly barometric pressures at Darjeeling (elevation 7,409 feet) for the seven monsoon seasons:—

TABLE XVI.

YEARS.	May.	June.	July.	August.	September.	October.	Season.
	″	″	″	″	″	″	″
1893 . . .	22·954	22·908	22·873	22·923	22·974	23·050	22·947
1894 . . .	·907	·875	·883	·885	·965	·014	·922
1895 . . .	·944	·917	·861	·897	·987	·016	·937
1896 . . .	·956	·883	·869	·914	·959	·061	·940
1897 . . .	·958	·878	·888	·922	23·002	·046	·949
1898 . . .	·942	·868	·875	·874	22·965	·036	·927
1899 . . .	·925	·898	·896	·930	23·008	·096	·959
Mean .	22·941	22·890	22·878	22·906	22·980	23·046	22·940

From the preceding data the following table has been constructed:—

TABLE XVII.

YEAR.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
	″	″	″	″	″	″	″
Mean preassure, Darjeeling . .	22·947	22·922	22·937	22·940	22·949	22 927	22·959
Departure from normal . . .	+·007	—·018	—·003	0	+·009	—·013	+·019
Abnormal change from season to season.	...	—·025	+·015	+·003	+·009	—·022	+·032

Here also the march of pressure is the same as at the sea level, though the changes are smaller than at the Ceylon hill station. This is shown in the curve given in Fig. 9, Plate LXXVI.

The two pressure oscillations are distinctly shown, but the periods are not quite the same in this as in the other curves, while the amplitudes of the oscillations are smaller, that of the first being ·025″ and that of the second ·032″.

Finally the observations at Wellington (elevation 6,200 ft.) have been dealt with in

the same manner. The following gives the mean monthly pressures of each monsoon season from 1893 to 1899 and the mean pressures of each season as a whole :—

TABLE XVIII.

YEARS.	May.	June.	July.	August.	September.	October.	Mean.
	"	"	"	"	"	"	"
1893	24·229	24·187	24·186	24·220	24·237	24·243	24·217
1894	·235	·174	·182	·172	·208	·241	·202
1895	·253	·187	·190	·188	·226	·250	·216
1896	·265	·173	·200	·211	·247	·303	·233
1897	·231	·170	·163	·177	·211	·258	·202
1898	·219	·171	·148	·203	·204	·237	·197
1899	·218	·178	·191	·195	·249	·266	·216
Mean	24·236	24·177	24·180	24·195	24·226	24 257	24·212

From the preceding data the following table has been constructed :—

TABLE XIX.

YEAR.	1893.	1894.	1895.	1896	1897.	1898.	1899.
	"	"	"	"	"	"	"
Mean pressure Wellington	24·217	24·202	24·216	24·233	24·202	24·197	24·216
Departure from normal	+·005	—·010	+·004	+·021	—·010	—·015	+·004
Abnormal change from season to season.	...	—·015	+·014	+·017	—·031	—·005	+·019

From the above it will be seen that pressure fell between the monsoon seasons of 1893 and 1894, rose between 1894 and 1895 and between 1895 and 1896, fell again between 1896 and 1897 and 1897 and 1898 and finally rose briskly between 1898 and 1899. This shows that at least at the elevation of 6,000 ft. the general march of pressure was the same as at the sea level. This march is shown in the curve given in Fig. 10, Plate LXXVI.

The above curve shows that the two pressure oscillations were well marked, the first running from 1893 to 1896 with its minimum in 1894 and the second running from 1896 to 1899 with its minimum in 1898. The amplitude of the first oscillation was ·031" and that of the second ·036", showing that the amplitudes of the oscillations were somewhat less at this elevation than at the level of the sea.

The preceding sections have shown that certain long period pressure oscillations have occurred over the Trades-Monsoon area during the seven years under review. It has also been shown that during these seven years the oscillations have been more or less identical both as regards time and amplitude in all parts of the Trades-Monsoon area. It is interesting in this connexion to note that this apparently has not always been the case, as Mr. Eliot, in the memoir already referred to, mentions that "a most remarkable

fact is that the Mauritius curve for nearly the whole of this period (*i.e.*, June 1891 to the end of 1894) was similar to and parallel with the variation curve for the Indian area, thus showing that the abnormal pressure conditions which prevailed in the Indian area extended in the same form and phase over the Indian Ocean." This extract shows that prior to June 1891 the Mauritius curve differed from the Indian curve. This dissimilarity disappeared in June 1891 and the likeness between the two curves was maintained more or less steadily throughout the whole of the seven years which are now under consideration, or for nine years in all.

Generalising from the preceding data it might be argued that it would be immaterial which curve was used for the purposes of connecting the main variations of rainfall with the main oscillations of pressure, but a close inspection of the curves on Plate LXXVII will show that the pressure over the oceanic tract of the South-East Trades area is, as might be expected, steadier and less liable to temporary fluctuations than the pressure over the Indian land area, so that the important pressure oscillations are better defined in the former than in the latter area. But even so there are numerous discrepancies which have to be reconciled and numerous anomalies to be discussed and considered before the oscillations can be made practically useful for the purpose of quantitative prediction of rainfall. The object of the present investigation is, however, to discuss the materials available over the Indian Seas which would afford a foundation for more or less generalised conclusions as to the actions which determine variations in the rainfall over India and to assign to each action its relative importance in the general scheme of prediction. So far as can be judged from the observations the most influential of these actions is the long period pressure oscillation, as it is the only one which exhibits a definite relation between its variations and the variations of rainfall. The observations appear also to show that the long period pressure oscillations are somewhat better defined over the oceanic tract of the South-East Trades region than over the Indian land area. There are also some reasons for supposing—founded on the experience of the year 1899—that the phases of the long period oscillations disclose themselves earlier in the South-East Trades region than in other parts of the Trades-Monsoon area.* The reasons for this are given in the following table :—

TABLE XX.

India.			South-East Trades.		
Years.	Pressure change between May of year and the preceding.	Pressure change between monsoon season of year and the preceding.	Pressure change between monsoon season of year and the preceding.	Pressure change between May of year and the preceding.	Years.
	"	"	"	"	
1894	—·011	—·018	—·029	—·021	1894
1895	+·016	+·025	+·013	+·011	1895
1896	+·020	+·002	+·016	+·005	1896
1897	—·018	—·020	—·016	—·008	1897
1898	—·004	—·001	—·021	—·038	1898
1899	—·010	+·024	+·045	+·032	1899

* A brief examination of the data appears to indicate that this, although of occasional occurrence, is not generally the case.—J.E.

The preceding data show that in most cases the phase of the oscillation which was to be characteristic of the monsoon season had already disclosed itself in May in both areas, but that in 1899 the high pressures which were to characterise the monsoon season of that year had appeared over the South-East Trades region in May, but had not appeared over the Indian land area. Consequently the pressure indications of May 1899 in the South-East Trades region might have been of practical use for forecasting the monsoon of that season when the pressure indications of India for May would have been misleading. This may have been purely fortuitous. The discussion on the failure of the rains in 1899 showed that the wave of high pressure, if this term may be employed, which formed the rising portions of the 1896—1899 pressure oscillation, spread over the Trades-Monsoon area from south to north, but this may not invariably be the case so that, whether the South-East Trades pressure curve has advantages, other than those of greater simplicity, over the India curve, only a very exhaustive study of all the seven years' data similar to that made in the case of 1899 would disclose.

The preceding discussion has shown that the oscillations in pressure to which attention has been drawn are general throughout the whole region from Lat. 20°S. (Mauritius) to Lat. 20° N. (the north of the Arabian Sea) as well as over the continent of India, and that the rainfall of India is affected by these oscillations in such a manner that when the monsoon circulation is established during the rising portion of one of these oscillations the Indian rainfall is less than usual, while when the monsoon period coincides with the falling portion of one of these oscillations, the Indian rainfall is increased and finally that when the monsoon season coincides with a rapid abnormal change of pressure the rainfall over India is then exceedingly excessive or deficient.

This conclusion leads to such important results that the investigation has been carried into the other half of the year, *viz.*, into that which includes the rainy season of the South-East Trades region and the dry season of India or from November to April. The curve given in Fig. 11, Plate LXXVI, derived from the records of Mauritius, Zanzibar and the Seychelles, shows the course of pressure in the South-East Trades region for each of the hot weather seasons (November to April) from 1893-94 to 1899-1900, the last period having been added in order to complete the last oscillation.

Comparing the above curve with the curve for the cold weather seasons of the South-East Trades region given in Fig. 1, it will be seen that the characteristics of the march of pressure are the same at both seasons. The two oscillations are well marked and of same period, but the amplitude of the first oscillation is ·024," and that of the second ·031", so that both the oscillations were of less amplitude in the hot than in the cold weather periods.

As at this period the weather is dry over India, while, on the contrary, it is the rainy season in the South-East Trades region, it will be of advantage to carry the investigation into the domain of the rainfall over the South-East Trades region, and the following table has hence been constructed. This table shows for each month of the years 1893—1899 the actual mean rainfall and its variation from the normal of the South-East Trades region

derived from the rainfall records of the three fixed observatories of Mauritius, Zanzibar and the Seychelles :—

TABLE XXI.

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1893*	+3·85	−0·37	−0·19	+4·59	+0·99	+0·13	−0·16	−0·06	−0·54	+0·25	−2·37	+2·56
	9·16	4·28	7·13	12·39	8·03	1·55	2·19	2·60	1·18	2·42	2·56	6·47
1894	+5·38	−2·06	−3·73	−1·79	−1·42	−0·89	+0·24	−0·20	−1·17	−0·02	+4·57	−0·97
	10·69*	2·59*	5·30	4·87	5·49	2·03	2·67	2·62	1·65	3·08	10·82	6·05
1895	−3·42	−3·16	+4·85	−2·64	−1·10	+0·80	−0·92	+0·11	+0·41	−0·46	+0·42	+2·96
	5·38	3·45	13·88	4·02	5·81	3·72	1·51	2·93	3·23	2·64	6·67	9·98
1896	+3·13	+10·68	−1·06	−0·75	+2·48	−0·52	−1·04	+0·68	+0·49	+0·92	+1·49	−1·65
	11·93	17·29	7·97	5·91	9·39	2·40	1·39	3·50	3·31	4·02	10·44	5·37
1897	−1·46	+0·02	+0·02	+2·08	−1·71	+3·53	+1·54	−1·04	−0·39	+0·35	−2·97	+1·34
	7·34	6·63	9·05	8·74	5·20	6·45	3·97	1·78	2·43	3·45	3·28	8·36
1898	+1·54	+0·81	+0·19	−3·78	−0·78	−1·16	−0·77	+0·29	−0·04	−0·93	−2·29	−0·70
	10·34	7·42	9·22	2·88	6·13	1·76	1·66	3·11	2·78	2·17	3·96	6·32
1899	−1·29	−4·07	+0·98	+3·03	+1·82	−0·86	+1·09	+0·34	+1·76	+0·61	−1·46	−0·62
	7·51	2·54	10·01	9·69	8·73	2·06	3·52	3·16	4·58	3·71	4·79	6·40

* Mauritius and Zanzibar only.

The preceding data show that the rainy season in this region runs roughly from November to April or May. Taking the six months from November to April as being the opposite of the six months employed in the investigation into the monsoon rainfall and comparing the mean pressure of the South-East Trades region with the rainfall variations of that region, the following table has been constructed giving the mean pressure of the South-East Trades region derived from the records of Mauritius, Zanzibar and the Seychelles for the period November to April (or the hot weather period) for each season from 1893-94 to 1899-00, together with the variation of pressure from the normal, the abnormal change of pressure between the season of date and the next preceding, and the variation of the rainfall of the South-East Trades region from the normal for the same period :—

TABLE XXII.

	1893 and 1894.	1894 and 1895.	1895 and 1896.	1896 and 1897.	1897 and 1898.	1898 and 1899.	1899 and 1900.	Mean.
	"	"	"	"	"	"	"	"
Mean pressure South-East Trades region.	29·890	29·875	29·887	29·899	29·873	29·870	29·901	29·885
Variation from normal	+·005	−·010	+·002	+·014	−·012	−·015	+·016	...
Abnormal change from season to season.	...	−·015	+·012	+·012	−·026	−·003	+·031	...
Rainfall variation over South-East Trades region.	−2·01	−0·77	+15·37*	+3·20	−2·87	−4·34	+1·01	...

* Three cyclones occurred in the South-East Trades region between January and March 1896.

The above data exhibit a connexion, as was the case in the monsoon rainfall over India, not between the actual pressures and the accompanying rainfall, but between the barometric change between one season and the previous one and the accompanying rainfall variations. Thus the mean barometric pressure of the rainy season 1893-94 was lower than that of 1892-93 and the rainfall was in defect. In 1894-95 the movement continued downward and the rainfall was deficient. In 1895-96 the pressure movement was upward and the accompanying rainfall variation was +15·37 inches. This upward movement continued in 1896-97 and the rainfall variation was +3·20 inches. Between 1896-97 and 1897-98 the pressure movement changed and the pressure decreased until the season of 1898-99, the accompanying rainfall variations in these two years having been −2·87″ inches and −4·34 inches, respectively. Between 1898-99 and 1899-1900 the pressure movement was upward and the rainfall variation was +1·01 inches. The above data indicate that a connexion exists between the oscillatory changes of pressure and the rainfall conditions of the South-East Trades region, but that the relation is the opposite of that prevailing over India. Thus should the rainy season in the South-East Trades region occur during the downward movement of pressure in its oscillation, then the accompanying rainfall will be in defect of the normal, while should the rainy season occur during the upward portion of any pressure oscillation, then the rainfall will be in excess of the normal. Another and curious difference between the conditions obtaining over India and over the South-East Trades region is that the maximum variations of rainfall occur in the South-East Trades region when the oscillatory changes of pressure are least, while over India, as shown before, the magnitude of the rainfall variations agrees directly with the velocity or extent of the pressure changes.

In order to trace the relation between the pressure changes and the rainfall variations over the South-East Trades region through the different months of each rainy season, the following table has been constructed giving the mean pressure of each month derived from the observations of Mauritius, Zanzibar and the Seychelles, the variations of pressure from the normal in each month, the abnormal change of pressure between one month and the next preceding month and the variation of rainfall from the average in each month of the different rainy seasons :—

TABLE—XXIII.

Years.		November.	December.	January.	February.	March.	April.
		″	″	″	″	″	″
1893-1894	Mean pressure	29·969	29·926	29·843	29·835	29·872	29·894
	Variation from normal	+·034	+·034	−·012	−·017	+·008	−·005
	Abnormal change	+·033	0	−·046	−·005	+·025	−·013
	Rainfall variation	−2·37	+2·56	+5·38	−2·06	−3·73	−1·79
1894-1895	Mean pressure	29·940	29·867	29·841	29·863	29·854	29·885
	Variation from normal	+·005	−·025	−·014	+·011	−·010	−·014
	Abnormal change	+·029	−·030	+·011	+·025	−·021	−·004
	Rainfall variation	+4·57	−0·97	−3·42	−3·16	+4·86	−2·64

TABLE—XXIII—*concld.*

YEARS.		November.	December.	January.	February.	March.	April.
1895-1896	Mean pressure	29″948	29″881	29″868	29″855	29″880	29″889
	Variation from normal	+·013	—·011	+·013	+·003	+·016	—·010
	Abnormal change	+·028	—·024	+·024	—·010	+·013	—·026
	Rainfall variation	+0·42	—2·96	+3·13	+1·068	—1·06	—·075
1896-1897	Mean pressure	29·932	29·921	29·866	29·854	26·876	29·943
	Variation from normal	—·003	+·029	+·011	+·002	+·012	+·044
	Abnormal change	—·019	+·032	—·018	—·009	+·010	+·032
	Rainfall variation	+4·19	—1.65	—1·46	+0·02	+0·02	+2·08
1897-1898	Mean pressure	29·915	29·876	29·896	29·832	29·847	29·873
	Variation from normal	—·020	—·016	+·041	—·020	—·017	—·026
	Abnormal change	—·041	+·004	+·057	—·061	+·003	—·009
	Rainfall variation	—2·97	+1·34	+1·54	+·081	+·019	—·378
1898-1899	Mean pressure	29·897	29·869	29·860	29·831	29·866	29·897
	Variation from normal	—·038	—·023	+·005	—·021	+·002	—·002
	Abnormal change	—·028	+·015	+·028	—·026	+·023	—·004
	Rainfall variation	—2·29	—0·70	—1·29	—4·07	+·098	+3·03

If the figures in the two last lines of each of the above rainy seasons be arranged in two columns, one representing the abnormal barometric change from one month to the next and the other the accompanying rainfall variation, the following table will be obtained :—

Abnormal downward movements of pressure.		Abnormal upward movements of pressure.	
Monthly pressure change. Inch.	Corresponding rainfall variation. Inches.	Monthly pressure change. Inch.	Corresponding rainfall variation. Inches.
—·046	+ 5·38	+·033	—2·37
—·005	— 2·06	+·025	—3·73
—·013	— 1·79	+·029	+4·57
—·030	— 0·97	+·011	—3·42
—·021	+ 4·85	+·025	—3·16
—·004	— 2·64	+·028	+0·42
—·024	+ 2·96	+·024	+3·13
—·010	+10·68	+·013	—1·06
—·026	— 0·75	+·032	—1·65
—·019	+ 4·19	+·010	+0·02
—·018	— 1·46	+·032	+2·08
—·009	+ 0·02	+·004	+1·34
—·041	— 2·97	+·057	+1·54
—·061	+ 0·81	+·003	+0·19
—·009	— 3·78	+·015	—0·70
—·028	— 2·29	+·028	—1·29
—·026	— 4·07	+·023	+0·98
—·004	+ 3·03		

The above shows that out of eighteen occasions on which the barometer exhibited an abnormal fall between one month and the next preceding month there were ten occasions on which the rainfall of the month in question was lighter than usual, while out of seventeen occasions on which the barometer exhibited an abnormal rise there were nine on which more rain than usual fell.

It is obvious from the above that the month to month pressure changes are of only slight value as indications of the subsequent rainfall, but this does not alter the fact that, taking the seasons as a whole, there exists a general agreement between the pressure change of the season of date and the next preceding season and the corresponding rainfall variation. This is shown below :—

TABLE XXIV.

Period.	Pressure change.	Rainfall variation.	Period.
	Inch.	Inches.	
Between 1893-94 and 1894-95 .	—·015	— 0·77	From November 1894 to April 1895.
„ 1894-95 and 1895-96 .	+·012	+15·37	„ „ 1895 „ 1896.
„ 1895-96 and 1896-97 .	+·012	+ 3·20	„ „ 1896 „ 1897.
„ 1896-97 and 1897-98 .	—·026	— 2·87	„ „ 1897 „ 1898.
„ 1897-98 and 1898-99 .	—·003	— 4·34	„ „ 1898 „ 1899.
„ 1898-99 and 1899-00 .	+·022	+ 1·01	„ „ 1899 „ 1900.

A consideration of all the preceding data leads to the conclusion that, during the period under review, the most important factor in the matter of rainfall over the Trades-Monsoon area was to be found in the pressure oscillations which were constantly in progress over that region. During the seven years under discussion two complete large oscillations of pressure have been recorded and the observations collected from the South-East Trades region as well as those from the Arabian Sea show that these oscillations prevailed throughout the whole region from Lat. 20° S. to Lat. 20°N. Moreover, the discussion has shown that when the monsoon or rainy season of India is included in the rising portion of a pressure oscillation that season will be one of deficient rainfall, and *vice versâ*. Similarly when the rainy season of the South-East Trades region (which occurs between November and April) is included in the rising portion of a pressure oscillation that rainy season will be one of excessive rain, and *vice versâ*. Hence the following conclusion is arrived at, *viz.*, that when considering the circumstances under which drought or flood occurred in the Trades-Monsoon area it was unnecessary to conceive a condition under which the South-East Trades were deflected or retarded to explain the deficiency of rain in one portion of the area and its excess in another. The circumstances under which rain fell over the Trades-Monsoon area, including in that area the whole of the Western Equatorial Belt, the Arabian Sea and the surrounding land areas were determined in their main features solely and simply by

the accidental relation which the time of the rainy season of any given region bore to the pressure condition in relation to the pressure oscillation then in progress. This is shown by the following reasoning :—

In the following table the smoothed monthly variations of pressure for the South-East Trades region and for India are given. These smoothed values are obtained by adding to each month's mean half of the means of the preceding and succeeding months and dividing the sum by two :—

TABLE XXV.

Years.	Division.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
		"	"	"	"	"	"	"	"	"	"	"	"
1893	South-East Trades	—·010	+·007	+·007	+·008	+·014	+·009	+·015	+·026	+·013	+·009	+·026	+·018
	India	—·011	—·003	+·007	—·005	—·005	+·009	+·015	+·004	—·011	—·001	+·024	+·020
1894	South-East Trades	—·001	—·009	—·002	—·002	—·003	—·006	—·019	—·025	—·022	—·015	—·009	—·020
	India	0	—·005	—·011	—·020	—·022	—·016	—·008	—·014	—·023	—·012	+·012	+·009
1895	South-East Trades	—·010	0	—·006	—·008	+·001	+·006	—·005	—·013	—·008	—·002	0	—·005
	India	—·001	—·003	—·003	0	+·005	+·013	+·013	+·004	+·006	+·014	+·017	+·007
1896	South-East Trades	+·005	+·009	+·006	+·002	+·001	+·007	+·019	+·020	+·011	+·008	+·010	+·011
	India	—·005	—·013	—·023	—·019	—·006	—·007	—·008	+·006	+·022	+·024	+·014	+·012
1897	South-East Trades	+·014	+·007	+·017	+·026	+·011	—·008	—·017	—·013	+·001	+·006	—·009	—·008
	India	—·003	—·024	—·009	+·013	+·005	—·007	—·007	—·002	+·004	—·004	—·007	+·004
1898	South-East Trades	+·012	—·003	—·020	—·026	—·027	—·024	—·025	—·027	—·025	—·023	—·027	—·025
	India	—·010	—·038	—·031	—·015	—·016	—·020	—·021	—·014	—·006	—·009	—·022	—·022
1899	South-East Trades	—·008	—·008	—·005	—·001	+·003	+·018	+·029	+·031	+·028	+·018	+·011	+·026
	India	—·019	—·024	—·016	—·008	—·008	+·001	+·006	+·011	+·028	+·034	+·025	+·010

The above shows greater unsteadiness of the barometer over India than over the South-East Trades region, though in general the two series of valves agree very closely. There are apparently minor oscillations of pressure over India which are not reproduced or are only faintly indicated by the pressure observations of the South-East Trades region and it is probably to these subsidiary oscillations that the minor variations of the rainfall in both

regions are attributable. In the mean time these subsidiary oscillations may be left out of the discussion and the primary oscillations which, as was observed above, are better shown in the pressure curve of the South-East Trades region than in that of the Indian region may be alone considered. The information given in the preceding table is reproduced in the Plate LXXVII, in which are given—(1st) the actual mean monthly pressure for each month of the year for the seven years 1893 to 1899 for the South-East Trades region shown by a thick broken line, (2nd) the smoothed pressure of the South-East Trades region shown by a thick continuous line, (3rd) the smoothed pressure of the Indian region shown by a thin continuous line, and (4th) the actual mean pressure of India shown by a thin broken line.

The above barometric curves and more particularly those of the South-East Trades region exhibit clearly the two pressure oscillations noticed in the preceding paragraphs. The first oscillation runs from August 1893 to April 1897. The principal features of the curve of this oscillation are, (1st) the rapidity of the fall from the maximum to the minimum. This fall was accomplished between August 1893 and August 1894 and was accompanied with heavier rain than usual over India and lighter rain than usual over the South-East Trades region. And (2nd) the slowness of the recovery. This recovery was spread over more than two years and lasted from September 1894 to April 1897. These two years were years of deficient rainfall over India and of excessive rainfall over the South-East Trades region. The second pressure oscillation lasted from May 1897 to September 1899 and was in one important respect the reverse of the first oscillation, for while the descent from the maximum, which occurred in April 1897, to the minimum, which occurred in December 1898, took twenty months to carry out, the recovery from the minimum to the maximum, which occurred in September 1899, took only nine months to carry out. Between the middle of April and the end of July the barometer fell quickly, and the monsoon rainfall of this year (1897) was heavy, but a recovery of pressure occurred in the latter part of the year, and, as mentioned above, the minimum of the oscillation was not reached until December 1898. The principal characteristic of the pressure conditions during the monsoon season of 1898 was extreme steadiness of the barometer. Pressure was very low from April to December, but the changes month by month were unimportant and consequently according to the rule that the monsoon rainfall varies according to the velocity of the pressure changes the rainfall of the monsoon season 1898 was about normal. From the middle of December 1898 the upward portion of the oscillation commenced and the rise to the maximum was carried out between December and September, a period of only nine months, so that following the above rule the monsoon rainfall of this season, 1899, was phenomenally light. The curve giving the actual barometric pressures, not the smoothed pressures, for the period January 1898 to September 1899 exhibits a very remarkable oscillation and the barometric fall, which, it will be noticed, occurred during the rainy season of the South-East Trades, was extraordinarily large between January and May 1898, and the rainfall of the Trades region was very light from March to July 1898. The pressure recovery between December 1898 and September 1899 was nearly as rapid as the previous fall and the rainfall in South Africa was heavy and exceptionally prolonged and the rainfall in India exceptionally light. This relation of the rainfall in the south to that in the north of the Trades-Monsoon area for the whole period under discussion is shown in the following table which gives the

rainfall variations of the South-East Trades region and for India for every month of the seven years under review :—

TABLE XXVI.

Years.	Division.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1893	South-East Trades	+3·85	− 0·37	−0·19	+4·59	+0·09	+0·13	−0·16	−0·06	−0·54	+0·25	−2·37	+2·36
	India	+0·52	+ 0·94	+0·87	+0·31	+1·59	+2·51	+0·07	−0·93	+1·27	+0·42	+1·21	−0·49
1894	South-East Trades	+5·38	− 2·06	−3·73	−1·79	−1·42	−0·89	+0·24	−0·20	−1·17	−0·02	+4·57	−0·97
	India	+0·11	+ 0·28	−0·12	+0·24	−0·55	+1·14	+1·07	+0·66	+0·94	+2·81	+0·48	−0·04
1895	South-East Trades	−3·42	− 3·16	+4·85	−2·64	−1·10	+0·80	−0·92	+0·11	+0·41	−0·46	+0·42	+2·96
	India	+0·05	− 0·16	−0·30	+0·38	−0·44	+0·09	−0·67	−0·09	−1·27	−0·25	−0·63	−0·02
1896	South-East Trades	+3·13	+10·68	−1·06	−0·75	+2·48	− 0·52	−1·04	+0·68	+0·49	+0·92	+4·19	−1·65
	India	−0·33	− 0·15	−0·41	−0·23	−0·29	+0·28	−0·39	+0·46	−2·98	−2·41	+0·45	+0·15
1897	South-East Trades	−1·46	+ 0·02	+0·02	+2·08	−1·71	+3·53	+1·54	−1·04	−0·39	+0·35	−2·97	+1·34
	India	−0·02	+ 0·13	+0·20	−0·21	−0·36	−0·73	−0·44	+2·46	+1·16	+0·31	−0·78	−0·45
1898	South-East Trades	+1·54	+ 0·81	+0·19	−3·78	−0·78	−1·16	−0·77	+0·29	−0·04	−0·93	−2·29	−0·70
	India	−0·36	+ 0·95	−0·68	−0·30	−0·68	−0·19	+0·45	+0·17	+1·32	−0·38	+0·36	+0·06
1899	South-East Trades	−1·29	− 4·07	+0·98	+3·03	+1·82	−0·86	+1·09	+0·34	+1·76	+0·61	−1·46	−0·62
	India	−0·19	− 0·08	−0·43	+1·51	−0·08	+1·49	−2·12	−2·79	−2·32	−0·67	−1·08	−0·48

Collecting these rainfall figures together under the rising and falling portions of the two pressure oscillations the following table is obtained :—

TABLE XXVII.

	Rising portions of the two pressure oscillations.		Falling portions of the two pressure oscillations.	
	September 1894 to April 1897.	December 1898 to September 1899.	August 1893 to August 1894.	May 1897 to November 1898.
	Variation of rainfall.	Variation of rainfall.	Variation of rainfall.	Variation of rainfall.
	Inches.	Inches.	Inches.	Inches.
South-East Trades region	+18·47	+2·10	−4·63	−6·67
India	− 4·87	−5·01	+4·26	+1·43
Rise or fall of pressure	+ ·071	+ ·063	− ·080	− ·082

The preceding data show very clearly the relation of the rainfall of the Trades-Monsoon area to the pressure oscillations, the rising portions of the oscillations having been accompanied with increased rain in the South-East Trades region and diminished rain in India and the falling portions having been accompanied with diminished rain in the South-East Trades region and increased rain in India. It was mentioned in an earlier paragraph that apparently rapid changes in the pressure oscillations were accompanied

with large rainfall variations over India and small rainfall variations over the South-East Trades region, and *vice versâ*. The preceding table appears to confirm this view. The pressure rise in the first oscillation was as much as 0·071″ but it was spread over a period of 30 months. During this period the South-East Trades region had an average monthly excess of rain of 0·60 inch and India an average monthly deficiency of only 0·16 inch. The rise in the second oscillation only amounted to 0·063″, but the change was carried out in nine months, and while the South-East Trades region had only an average monthly excess of rain of 0·31 inch, India had an average monthly deficiency of 0·56 inch. This relation is shown very completely and concisely in the second pressure oscillation of the series. Pressure had reached its maximum in April 1897 and commenced to fall in May, reaching its minimum in December 1898. It then commenced to rise and rose steadily and quickly until September 1899. The accompanying rainfall conditions over the Trades-Monsoon region are shown in the following table which gives the rainfall variations of the different portions of that area for the different phases of the oscillation:—

TABLE XXVIII.

Division.	Falling portion of the pressure oscillation.	Rising portion of the pressure oscillation.
	May 1897 to December 1898.	January to September 1899.
	Variation of rainfall.	Variation of rainfall.
	Inches.	Inches.
South-East Trades region	−6·97	+2·80
India	+1·89	−5·01

It practically follows from the preceding data and discussions that the rainfall over the Trades-Monsoon area, apart from that due to cyclones and other accidental disturbances, is, in its main outlines, solely and simply a function of the pressure oscillations, the signs of the rainfall variations changing at the Equator. These rainfall conditions are brought about or produced by the pressure oscillation, irrespective of any alterations in the direction of movement or in the velocity of movement of the winds and without regard to the actual height of the barometer, etc., over the region in question. Thus it follows that in different years the records show large variations of rainfall with, at the same time, hardly any variations in the surface meteorological conditions. Thus it also follows that the phenomenal deficiency of rain over India during 1899 and the large excess over South Africa were in no way compensatory nor did they stand in the relation of cause and effect but both were alike results of the rapid rise of pressure over the Trades-Monsoon area due to the completion of a pressure oscillation of large amplitude within the space of a few months, a change which, *ipso facto*, determined excessive rain to the south Equatorial and deficient rain to the north Equatorial portions of the area.

PART III.

OTHER METEOROLOGICAL PHENOMENA IN RELATION TO THE TRADES-MONSOON RAINFALL.

It is not, however, sufficient to show that the pressure oscillations appear in themselves sufficient, to account for the main rainfall conditions of the Trades-Monsoon area, it is necessary also to show that the other meteorological conditions prevailing over the region exercise no appreciable effect on these variations. This is done in the following sections. The Plates LXXIV and LXXV show the mean distribution of pressure and the average wind direction over the Equatorial Belt and over the Arabian Sea for each of the monsoon seasons 1893—99. They show hardly any variation in the general conditions from one season to the next and certainly none which would account for the very large variations of rainfall which the preceding data have shown to have occurred over the Trades-Monsoon area during the seven seasons under review.

Barometric Gradients in Equatorial Regions (1st) Mauritius and Seychelles.—The first point, which promised to repay investigation, was that of the barometric gradient or pressure difference over the South-East Trades region. The Royal Alfred Observatory, Mauritius, lies in Lat. 20°6′S. and Long. 57°33′E., and the Observatory at Port Victoria, Seychelles, in Lat. 4°37′S. and Long. 55°27′E., so that the latter is about 950 miles almost due north of the former and during the monsoon months the barometer, properly corrected, reads steadily higher at Mauritius than at the Seychelles. For 1893 there are no observations from the Seychelles, but from 1894 to 1899 the record is complete. The following gives the mean pressures of the monsoon months (May to October) for the two stations, Mauritius and the Seychelles, from 1894 to 1899:—

1894 (May to October)	Mauritius	30·087	difference	=	0·195″
	Seychelles	29·892			
1895 (May to October)	Mauritius	30·098	difference	=	0·199″
	Seychelles	29·899			
1896 (May to October)	Mauritius	30·125	difference	=	0·208″
	Seychelles	29·917			
1897 (May to October)	Mauritius	30·107	difference	=	0·219″
	Seychelles	29·888			
1898* (May to October)	Mauritius	30·090	difference	=	0·209″
	Seychelles	29·881			
1899 (May to October)	Mauritius	30·134	difference	=	0·212″
	Seychelles	29·922			

* October wanting.

To compare these pressure differences with the abnormal rainfall conditions over India the following table has been constructed:—

TABLE XXIX.

YEARS.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	Mean seasonal pressure difference.
	"	"	"	"	"	"	"	"
Mean pressure difference (May to October) between Mauritius and Seychelles.	...	·195	·199	·208	·219	·209	·212	·207
Variation of pressure difference from normal.	...	— ·012	— ·008	+ ·001	+ ·012	+ ·002	+ ·005	...
Rainfall variations (May to October) over India.	+4·88	+6·07	−2·63	−5·33	+2·40	+0·69	−6·49	...

The above does not appear to hold out any expectation of the barometric difference or gradient over the South-East Trades region assisting in forecasting the monsoon rainfall over India. In 1894 and 1895 the pressure differences were 0·195" and 0·199", respectively, while there was a difference of over 8 inches in the mean rainfall of the two seasons, and while the average differences of the monsoon months of the years 1896 and 1898 were almost identical ('209"), the rainfall variations over India were in the former case −5·33 inches and in the latter +0·69 inch. There does not appear to be any system underlying the changes in the amount of the pressure difference and in the amount of the rainfall variation, but in order to make sure of this conclusion the following table has been prepared showing for each month of each season the barometric differences over the South-East Trades region and the rainfall variation over India:—

TABLE XXX.

	MONTHS.	May.	June.	July.	August.	September.	October.
		"	"	"	"	"	"
1894	Mean pressure difference, Mauritius and Seychelles.	·142	·209	·218	·245	·202	·150
	Rainfall variation over India.	−0·55	+1·14	+1·07	+0·66	+0·94	+2·81
	Variation of pressure difference from normal.	—·025	—·007	—·014	—·001	—·011	—·010
1895	Mean pressure difference, Mauritius and Seychelles.	·179	·227	·204	·214	·203	·169
	Rainfall variation over India.	−0·44	+0·09	−0·67	−0·09	−1·27	−0·25
	Variation of pressure difference from normal.	+·012	+·011	—·028	—·032	—·010	+·009
1896	Mean pressure difference, Mauritius and Seychelles.	·145	·223	·219	·265	·229	·163
	Rainfall variation over India.	−0·29	+0·28	−0·39	+0·46	−2·98	−2·41
	Variation of pressure difference from normal.	—·022	+·007	—·013	+·019	+·016	+·003

TABLE XXX—*concld.*

	Months.	May.	June.	July.	August.	September.	October.
		"	"	"	"	"	"
1897	Mean pressure difference, Mauritius and Seychelles.	·196	·219	·247	·254	·236	·160
	Rainfall variation over India.	—0·36	—0·93	—0·44	+2·46	+1·16	+0·31
	Variation of pressure difference from normal.	+·029	+·003	+·015	+·008	+·023	0
1898	Mean pressure difference, Mauritius and Seychelles.	·169	·227	·230	·221	·210	?
	Rainfall variation over India.	—0·68	—0·19	+0·45	+0·17	+1·32	—0·38
	Variation of pressure difference from normal.	+·002	+·011	—·002	—·025	—·003	?
1899	Mean pressure difference, Mauritius and Seychelles.	·168	·192	·276	·279	·199	·160
	Rainfall variation over India.	—0·08	+1·49	—2·12	—2·79	—2·32	—0·67
	Variation of pressure difference from normal.	—·001	—·024	+·044	+·033	—·014	0
	Normal pressure difference.	·167	·216	·232	·246	·213	·160

The only generalisation possible from the preceding data is to the effect that when the barometric difference is greater than usual over this portion of the South-East Trades region then the mean rainfall over India is *less* than usual, and that when the barometric difference in the South-East Trades region is less than usual the rainfall in India *exceeds* the normal. Grouping the phenomena together it would appear that the generalised result would be as shown below:—

Abnormal pressure difference.	Corresponding rainfall variation.	Abnormal pressure difference.	Corresponding rainfall variation.
Inch.	Inches.	Inch.	Inches.
—·025	—0·55	+·012	—0·44
—·007	+1·14	+·011	+0·09
—·014	+1·07	+·009	—0·25
—·001	+0·66	+·007	+0·28
—·011	+0·94	+·019	+0·46
—·010	+2·81	+·016	—2·98
—·028	—0·67	+·003	—2·41
—·032	—0·09	+·029	—0·36
—·010	—1·27	+·003	—0·93
—·022	—0·27	+·015	—0·44
—·013	—0·39	+·008	+2·46
—·002	+0·45	+·023	+1·16
—·025	+0·17	+·002	—0·68
—·003	+1·32	+·011	—0·19
—·001	—0·08	+·044	—2·12
—·024	+1·49	+·033	—2·79
—·014	—2·32		
—·242	+4·4	+·245	—9·14
—·014	+0·26	+·015	—0·57

The preceding data show that even if the variation in the extent of the barometric difference between Mauritius and the Seychelles be accompanied with a variation in the rainfall over India the variation is small and practically of no importance, while the irregularity of the relation between the march of the two phenomena, as shown both in the seasonal and monthly returns, makes it very doubtful whether any such relation really exists.

(2nd) Mauritius and Zanzibar.—Similarly if the barometric difference between Mauritius and Zanzibar be investigated the following statement will be produced :—

1893 (May to October)	Mauritius	30·113	difference =	0·090″
	Zanzibar	30·023		
1894 (May to October)	Mauritius	30·087	difference =	0·083″
	Zanzibar	30·004		
1895 (May to October)	Mauritius	30·098	difference =	0·076″
	Zanzibar	30·022		
1896 (May to October)	Mauritius	30·125	difference =	0·098″
	Zanzibar	30·027		
1897 (May to October)	Mauritius	30·107	difference =	0·081″
	Zanzibar	30·026		
1898 (May to October)	Mauritius	30·090	difference =	0·097″
	Zanzibar	29·993		
1899 (May to October)	Mauritius	30·134	difference =	0·097″
	Zanzibar	30·037		

Dealing with these values in the same way as with the Mauritius-Seychelles values the following table is constructed :—

TABLE XXXI.

YEARS.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	Mean.
	″	″	″	″	″	″	″	″
Mean pressure difference (May to October) between Mauritius and Zanzibar . .	·090	·083	·076	·098	·081	·097	·097	·091
Variation of mean pressure difference from normal	—·001	—·008	—·015	+·007	—·010	+·006	+·006	
Rainfall variation (May to October) over India	+4·88	+6·07	—2·63	—5·33	+2·40	+0·69	—6·49	

It seems difficult to come to any other conclusion than that the pressure difference between Mauritius and Zanzibar has no effect on the determination of more or less rainfall to the Indian region during the monsoon months.

(3rd) Zanzibar and the Seychelles.—In order to complete the investigation into the pressure conditions over Equatorial regions and their relations to Indian monsoon rainfall a similar statement to those given for Mauritius and the Seychelles and for Mauritius and

Zanzibar has been prepared for the area lying between Zanzibar and the Seychelles. The following gives this statement:—

1894 (May to October)	Zanzibar	30·004	difference = 0·112″
	Seychelles	29·892	
1895 „ „	Zanzibar	30·022	difference = 0·123″
	Seychelles	29·899	
1896 „ „	Zanzibar	30·027	difference = 0·110″
	Seychelles	29·917	
1897 „ „	Zanzibar	30·026	difference = 0·138″
	Seychelles	29·888	
1898 „ „	Zanzibar	29·993	difference = 0·112″
	Seychelles	29·881	
1899 „ „	Zanzibar	30·037	difference = 0·115″
	Seychelles	29·922	

In order to compare these pressure differences with the rainfall variations over India the following table has been constructed:—

TABLE XXXII.

YEARS.	1894	1895	1896	1897	1898	1899	Mean.
	″	″	″	″	″	″	″
Mean pressure difference (May to October) between Zanzibar and Seychelles.	·112	·123	·110	·138	·112	·115	·118
Variation of pressure difference from normal.	—·006	+·005	—·008	+·020	—·006	—·003	
Rainfall variation (May to October) over India.	+6·07	—2·63	—5·33	+2·40	+0·69	—6·49	

Here again there is absolutely no indication of any relation existing between the variations in the pressure differences or barometric gradient in Equatorial regions and the variations in the amount of rainfall over India.

So far then as pressure is concerned the present investigation appears to show that variations in the actual height of the barometer as well as in the barometric differences or gradients over the Equatorial area are not influential in modifying the rainfall over India to an extent which is appreciable in our existing records.

Barometric gradients over the Equatorial Belt and the Arabian Sea.—Before taking leave of the investigation into the barometrical conditions in Equatorial regions in relation to Indian weather it will be convenient to consider here the question of the variations of barometric differences between (1) Mauritius and Bombay, and (2) the Seychelles and Bombay in the different monsoon seasons. The question affects conditions both over the Equatorial region and over the Arabian Sea, but may as conveniently be referred to here as in a subsequent section. The following shows the pressure

differences between Mauritius and Bombay for each of the monsoon months and for each monsoon season :—

TABLE XXXIII.

YEAR.	MONTH.	Mean pressure, Mauritius.	Mean pressure, Bombay.	Difference.	Mean difference for season.
		"	"	"	
1893	May	30·051	29·741	·310	·401
	June	·106	·637	·469	
	July	·157	·675	·482	
	August	·225	·717	·508	
	September	·140	·763	·377	
	October	·072	·814	·258	
1894	May	·016	·772	·244	·375
	June	·103	·626	·477	
	July	·116	·647	·469	
	August	·139	·683	·456	
	September	·110	·746	·364	
	October	·036	·796	·240	
1895	May	·050	·782	·268	·368
	June	·105	·641	·464	
	July	·142	·676	·466	
	August	·113	·688	·425	
	September	·134	·789	·345	
	October	·046	·807	·239	
1896	May	·039	·784	·255	·384
	June	·105	·602	·503	
	July	·178	·654	·524	
	August	·204	·726	·478	
	September	·143	·811	·332	
	October	·079	·866	·213	
1897	May	·049	·763	·286	·396
	June	·086	·651	·435	
	July	·131	·617	·514	
	August	·151	·659	·492	
	September	·142	·746	·396	
	October	·084	·829	·255	

TABLE XXXIII—*concld.*

YEARS.	MONTH.	Mean pressure, Mauritius.	Mean pressure, Bombay.	Difference.	Difference for season.
		"	"	"	
1898	May	30·007	29·748	·259	·372
	June	·099	·636	·463	
	July	·121	·614	·507	
	August	·128	·735	·393	
	September	·093	·746	·347	
	October	·057	·796	·261	
1899	May	·030	·744	·286	·378
	June	·107	·647	·460	
	July	·220	·724	·496	
	August	·209	·749	·460	
	September	·161	·836	·325	
	October	·078	·836	·242	

Combining these differences into tabular form, the following statement is obtained:—

TABLE XXXIV.

YEAR.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	Mean.
	"	"	"	"	"	"	"	"
Barometric difference between Mauritius and Bombay (May to October).	·401	·375	·368	·384	·396	·372	·378	·382
Variation from normal	+·019	—·007	—·014	+·002	+·014	—·010	—·004	
Departure of Indian rainfall from normal	+4·88	+6·07	—2·63	—5·33	+2·40	+0·69	—6·49	

It appears to the writer impossible to reconcile the march of these two phenomena or to connect them together for practical purposes. In 1894 the pressure difference amounted to ·375″ and in 1899 to ·378″, while in one case the rainfall variation was +6·07 inches and in the other —6·49 inches.

Turning next to the Seychelles the following gives the monthly and seasonal pressure differences between the Seychelles and Bombay for the monsoons of 1894 to 1899:—

TABLE XXXV.

Year.	Months.	Mean pressure, Seychelles.	Mean pressure, Bombay.	Difference.	Difference for season.
		"	"	"	
1894	May	29·874	29·772	0·102	·181
	June	·894	·626	·268	
	July	·898	·647	·251	
	August	·894	·683	·211	
	September	·908	·746	·162	
	October	·886	·796	·090	
1895	May	·871	·782	·089	·169
	June	·878	·641	·237	
	July	·938	·676	·262	
	August	·899	·688	·211	
	September	·931	·789	·142	
	October	·877	·807	·070	
1896	May	·894	·784	·110	·177
	June	·882	·602	·280	
	July	·959	·654	·305	
	August	·939	·726	·213	
	September	·914	·811	·103	
	October	·916	·866	·050	
1897	May	·853	·763	·090	·178
	June	·867	·651	·216	
	July	·884	·617	·267	
	August	·897	·659	·238	
	September	·906	·746	·160	
	October	·924	·829	·095	
1898	May	838	·748	·090	·169
	June	·872	·636	·236	
	July	·891	·614	·277	
	August	·907	·735	·172	
	September	·883	·746	·137	
	October	·895	·796	·099	

TABLE XXXV—*concld.*

YEAR.	MONTHS.	Mean pressure, Seychelles.	Mean pressure, Bombay.	Difference.	Difference for season.
		"	"	"	
1899	May	29·862	29·744	·118	·166
	June	·915	·647	·268	
	July	·944	·724	·220	
	August	·930	·749	·181	
	September	·962	·836	·126	
	October	·918	·836	·082	

Combining these differences into tabular form, the following table is obtained :—

TABLE XXXVI.

YEARS.	1894.	1895.	1896.	1897.	1898.	1899.	Mean.
	"	"	"	"	"	"	"
Barometric difference between Seychelles and Bombay (May to October).	·181	·169	·177	·178	·169	·166	·173
Variation from normal	+·008	—·004	+·004	+·005	—·004	—·007	
Rainfall variation over India	+6·07	—2·63	—5·33	+2·40	+0·69	—6·49	

It is remarkable how small is the variation in the pressure difference from year to year between the Seychelles and Bombay, while it is perhaps not altogether a mere coincidence that the year of greatest pressure difference is that of heaviest rainfall, while that of least pressure difference is that of lightest rainfall, but the years 1895 and 1898 exhibit an identical pressure difference, while the rainfall variation over India in the one case was —2·63 inches and in the other +0·69 inch.

Winds.

Turning next to the winds recorded over the South-East Trades region it is at once obvious that the variations in the wind directions are exceedingly small from season to season.

The following table shows the mean wind direction of the monsoon months (May to October) over the South-East Trades region as represented by the returns from Mauritius, Zanzibar and the Seychelles :—

TABLE XXXVII.

YEARS.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	Mean.
Mean wind direction (May to October) for South-East Trades region.	° S 45 E	° S 39 E	° S 32 E	° S 38 E	° S 38 E	° S 39 E	° S 32 E	° S 38 E
Departure from normal or easterly deflection.	° +7	° +1	° −6	° 0	° 0	° +1	° −6	
Rainfall variation over India	" +4·88	" +6·07	" −2·63	" −5·33	" +2·40	" +0·69	" −6·49	

The principal feature of the preceding data is the extreme steadiness of the South-East Trade winds during the monsoon season of each year. There was slightly more easting than usual in the wind's direction in 1893, but the mean direction of this season is not altogether reliable as there were no observations for the Seychelles for that season and the mean direction for that station for that season has been interpolated. On the other hand, there was somewhat less easting than usual in the South-East Trades region in 1895 and 1899. In all the remaining years the variations from the normal were exceedingly small. In the year of phenomenal rainfall failure, 1899, the wind varied only by 6° from the normal and, so far from exhibiting an abnormal amount of easting, the mean wind direction was even more southerly than the average. The two sets of variations are, however, so incongruous that it is almost impossible to believe in any relation existing between the two phenomena. Whether the decreased easting in the South-East Trades and the decreased rainfall over India noticed above is a real relation or not it is impossible to say from the scanty data at our disposal at present, but the available data do not support the explanation that when the monsoon rainfall over India is scanty it is because there has been an abnormal deflection of the *surface* South-East Trades towards Africa. Whether in the upper atmosphere, where friction is small, the current fails, in some years, to curve round into south and south-west, but rather continues to travel on towards the north-west and thus forms an ascensional current over Central Africa is a mere conjecture with which we have no present concern, dealing as we

are with purely observational records. Taking the three stations separately the following table is obtained :—

TABLE XXXVIII.

YEAR.	1893	1894	1895	1896	1897	1898	1899	Mean.
Mean wind direction (May to October) Mauritius.	S 77° E	S 69° E	S 68° E	S 66° E	S 68° E	S 67° E	S 64° E	S 68° E
Variation (Easterly deflection) . .	+9°	+1°	0°	−2°	0°	−1°	−4°	
Mean wind direction (May to October) Zanzibar.	S 11° E	S 15° E	S 2° E	S 6° E	S 12° E	S 4° E	S 2° E	S 7° E
Variation (Easterly deflection) . .	+4°	+8°	−5°	−1°	+5°	−3°	−5°	
Mean wind direction (May to October) Seychelles.	...	S. 36° E	S 36° E	S 38° E	S 32° E	S 43° E	S 35° E	S 38° E
Variation (Easterly deflection) . .		−2°	−2°	0°	−6°	+5°	−3°	
Rainfall variation over India . .	+4·88″	+6·07″	−2·63″	−5·33″	+2·40″	+0·69″	−6·49″	

Taking the stations separately the same general results are obtained as when the three are combined.

As the question, of the dependence of the rainfall of India on the direction of the winds in the South-East Trades region, is one of great importance, the above table has been amplified and the following tables give for each monsoon month of each year the mean actual winds of each station and the corresponding rainfall anomaly over India :—

TABLE XXXIX.

Mauritius.

YEAR.	MONTH.	Normal mean wind direction.	Actual mean wind direction.	Easterly deflection.	Variation of rainfall over India.
		°	°	°	Inches.
1893	June	S 64 E	S 65 E	+ 1	+2·51
	July	S 66 E	S 72 E	+ 6	+0·07
	August	S 68 E	S 75 E	+ 7	−0·98
	September	S 73 E	S 83 E	+10	+1·27
	October	S 78 E	S 88 E	+10	+0·42
1894	June	S 64 E	S 61 E	− 3	+1·14
	July	S 66 E	S 65 E	− 1	+1·07
	August	S 68 E	S 68 E	0	+0·66
	September	S 73 E	S 71 E	− 2	+0·94
	October	S 78 E	S 76 E	− 2	+2·81
1895	June	S 64 E	S 62 E	− 2	+0·09
	July	S 66 E	S 63 E	− 3	−0·67
	August	S 68 E	S 68 E	0	−0·09
	September	S 73 E	S 74 E	+ 1	−1·27
	October	S 78 E	S 80 E	+ 2	−0·25

TABLE XXXIX—*concld.*

YEAR.	MONTH.	Normal mean wind direction.	Actual mean wind direction.	Easterly deflection.	Variation of rainfall over India.
		°	°	°	Inches.
1896	June	S 64 E	S 66 E	+ 2	+0·28
	July	S 66 E	S 62 E	— 4	—0·39
	August	S 68 E	S 60 E	— 8	+0·46
	September	S 73 E	S 77 E	+ 4	—2·98
	October	S 78 E	S 82 E	+ 4	—2·41
1897	June	S 64 E	S 63 E	— 1	—0·73
	July	S 66 E	S 69 E	+ 3	—0·44
	August	S 68 E	S 69 E	+ 1	+2·46
	September	S 73 E	S 74 E	+ 1	+1·16
	October	S 78 E	S 79 E	+ 1	+0·31
1898	June	S 64 E	S 67 E	+ 3	—0·19
	July	S 66 E	S 67 E	+ 1	+0·45
	August	S 68 E	S 70 E	+ 2	+0·17
	September	S 73 E	S 67 E	— 6	+1·32
	October	S 78 E	S 72 E	— 6	—0·38
1899	June	S 64 E	S 63 E	— 1	+1·14
	July	S 66 E	S 67 E	+ 1	—2·12
	August	S 68 E	S 67 E	— 1	—2·79
	September	S 73 E	S 67 E	— 6	—2·32
	October	S 78 E	S 72 E	— 6	—0·67

The preceding data show that there were eighteen months out of the thirty-five in which the wind was more easterly than usual, and of these eighteen months ten had more and eight had less rainfall over India than the average. The following gives a resume of the data contained in the above table :—

(1) Increased easting accompanied with diminished rain over India 8 months.
(2) „ „ „ „ increased „ „ „ 10 „
(3) Diminished „ „ „ diminished „ „ „ 7 „
(4) „ „ „ „ increased „ „ „ 8 „

So far then as the evidence of these seven monsoon seasons is concerned the slight variations in the wind direction at Mauritius bear little or no relation to the rainfall vaiations over India.

TABLE XL.

Zanzibar.

YEAR.	MONTH.	Normal mean wind direction.	Actual mean wind direction.	Easterly deflection.	Variation of rainfall over India.
		°	°	°	*Inches.*
1893	June	S 5 E	?	?	+2·51
	July	S 7 E	S 13 E	+ 6	+0·07
	August	S 9 E	S 16 E	+ 7	−0·98
	September	S 3 E	S 25 E	+22	+1·27
	October	S 8 E	S 12 E	+ 4	+0·42
1894	June	S 5 E	S 5 E	0	+1·14
	July	S 7 E	S 2 E	− 5	+1·07
	August	S 9 E	S 1 E	− 8	+0·66
	September	S 3 E	S 2 E	− 1	+0·94
	October	S 8 E	S 9 E	+ 1	+2·81
1895	June	S 5 E	S 6 E	+ 1	+0·09
	July	S 7 E	S 6 E	− 1	−0·67
	August	S 9 E	S 13 E	+ 4	−0·09
	September	S 3 E	S 16 W	−19	−1·27
	October	S 8 E	S 2 W	−10	−0·25
1896	June	S 5 E	S 5 E	0	+0·28
	July	S 7 E	S 8 E	+ 1	−0·39
	August	S 9 E	S 12 E	+ 3	+0·46
	September	S 3 E	S 7 E	+ 4	−2·98
	October	S 8 E	S 1 E	− 7	−2·41
1897	June	S 5 E	S 2 E	− 3	−0·73
	July	S 7 E	S 2 E	− 5	−0·44
	August	S 9 E	S 6 E	− 3	+2·46
	September	S 3 E	S 10 E	+ 7	+1·16
	October	S 8 E	S 55 E	+47	+0·31
1898	June	S 5 E	S 8 E	+ 3	−0·19
	July	S 7 E	S 10 E	+ 3	+0·45
	August	S 9 E	S 8 E	− 1	+0·17
	September	S 3 E	S 2 W	− 5	+1·32
	October	S 8 E	S 7 W	−15	−0·38
1899	June	S 5 E	S 4 E	− 1	+1·49
	July	S 7 E	S 8 E	+ 1	−2·12
	August	S 9 E	S 8 E	− 1	−2·79
	September	S 3 E	S 2 W	− 5	−2·32
	October	S 8 E	S 5 W	−13	−0·67

The above table shows that there were fifteen months out of the thirty-four under review during which the wind at Zanzibar was more easterly than usual, and out of these fifteen months in nine there was more, and in six there was less, rainfall over India than the normal. The following gives a resume of the above table:—

(1) Increased easting accompanied with diminished rain over India 6 months.
(2) " " " " increased " " " 9 "
(3) Diminished " " " diminished " " " 10 "
(4) " " " " increased " " " 7 "

As before mentioned the number of months with which we are dealing is so evenly divided among the different headings given above that it is practically impossible to deduce any rule from the preceding data.

TABLE XLI.

Seychelles.

Year.	Month.	Normal mean wind direction.	Actual mean wind direction.	Easterly deflection.	Variation of rainfall over India.
		°	°	°	Inches.
1894	June	S 22 E	S 19 E	— 3	+1·14
	July	S 33 E	S 22 E	—11	+1·07
	August	S 33 E	S 27 E	— 6	+0·66
	September	S 39 E	S 40 E	+ 1	+0·94
	October	S 38 E	S 57 E	+19	+2·81
1895	June	S 22 E	S 11 E	—11	+0·09
	July	S 33 E	S 36 E	+ 3	—0·67
	August	S 33 E	S 34 E	+ 1	—0·09
	September	S 39 E	S 39 E	0	—1·27
	October	S 38 E	S 21 E	—17	—0·25
1896	June	S 22 E	S 29 E	+ 7	+0·28
	July	S 33 E	S 29 E	— 4	—0·39
	August	S 33 E	S 35 E	+ 2	+0·40
	September	S 39 E	S 46 E	+ 7	—2·98
	October	S 38 E	S 53 E	+15	—2·41
1897	June	S 22 E	S 31 E	+ 9	—0·73
	July	S 33 E	S 34 E	+ 1	—0·44
	August	S 33 E	S 35 E	+ 2	+2·46
	September	S 39 E	S 36 E	— 3	+1·16
	October	S 38 E	S 31 E	— 7	+0·31

TABLE XLI—*concld.*

YEAR.	MONTH.	Normal mean wind direction.	Actual mean wind direction.	Easterly deflection.	Variation of rainfall over India.
		°	°	°	Inches.
1898	June	S 22 E	S 18 E	— 4	—0·19
	July	S 33 E	S 36 E	+ 3	+0·45
	August	S 33 E	S 34 E	+ 1	+0·17
	September	S 39 E	S 41 E	+ 2	+1·32
	October	S 38 E	S 31 E	— 7	—0·38
1899	June	S 22 E	S 22 E	0	+1·49
	July	S 33 E	S 41 E	+ 8	—2·12
	August	S 33 E	S 32 E	— 1	—2·79
	September	S 39 E	S 30 E	— 9	—2·32
	October	S 38 E	S 37 E	— 1	—0·67

For the station of the Seychelles there are only six seasons' observations. They show that out of the thirty months under review there were fifteen months or exactly half during which the wind at the Seychelles was more easterly than usual, and out of these fifteen months in eight there was more and in seven there was less rain than usual over India. The following gives a resume of the preceding table :—

(1) Increased easting accompanied with diminished rain over India 7 months.
(2) „ „ „ „ increased „ „ „ 8 „
(3) Diminished „ „ „ diminished „ „ „ 7 „
(4) „ „ „ „ increased „ „ „ 6 „

Turning next to the wind velocities as deduced from these three stations the following table shows the variations of the wind velocities from the normal over the South-East Trades region during the seven monsoon seasons :—

TABLE XLII.

YEARS.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	MEAN.
Mean wind velocity in miles per diem (May to October) for South-East Trades region.	238	234	223	224	224	230	233	229
Departure from normal	+9	+5	—6	—5	—5	+1	+4	
Rainfall variation over India . . .	+4·88"	+6·07"	—2·63"	—5·33"	+2·40"	+0·69"	—6·49"	

This investigation also does not exhibit any real agreement between the mean velocity of the wind and the rainfall variations. Thus 1893, 1894 and 1898 had an excessive velocity and excessive rainfall, but 1899 had also an excessive velocity, while it had a large deficiency of rainfall. On the other hand, 1895, 1896 and 1897 had a diminished velocity, but, while 1895 and 1896 had a diminished rainfall, 1897 had excessive rain.

Taking the three stations separately, as was done in the case of the wind direction the following table is obtained:—

TABLE XLIII.

YEARS.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	MEAN.
Mean wind velocity in miles per diem (May to October) Mauritius.	254	243	258	269	301	278	275	268
Variation	−14	−25	−10	+ 1	+33	+10	+ 7	
Mean wind velocity in miles per diem (May to October) Zanzibar.	221	209	151	143	145	175	158	172
Variation	+49	+37	−21	−9	−27	+ 3	−14	
Mean wind velocity in miles per diem (May to October) Seychelles.	...	251	259	259	226	237	266	249
Variation	...	+ 2	+10	+10	−23	−12	+17	
Rainfall variation over India . .	+4·88″	+6·07″	−2·63″	−5·33″	+2·40″	+0·69″	−6·49″	

This analysis shows that so far as can be determined there exists no real relation between the velocity of the wind in the South-East Trades region and the accompanying rainfall over India. It likewise shows that there are large variations in the wind velocity within that region. Thus the variations in the velocities at Mauritius and Zanzibar are largely the opposite of one another and in the case of Zanzibar the higher winds are generally accompanied with increased rainfall in India. In order to test this suggested connexion the following tables have been constructed:—

TABLE XLIV.

Zanzibar.

YEAR.	MONTH.	Normal velocity. Miles in 24 hours.	Actual velocity. Miles in 24 hours.	Variation. Miles. in 24 hours.	Variation of rainfall over India.
					Inches.
1893	June	221	267	+46	+2·51
	July	199	266	+67	+0·07
	August	170	234	−64	−0·98
	September	134	168	+34	+1·27
	October	112	144	+32	+0·42
1894	June	221	263	+42	+1·14
	July	199	262	+63	+1·07
	August	170	184	+14	+0·66
	September	134	184	+50	+0·94
	October	112	148	+36	+2·81

TABLE XLIV—*concld.*

YEAR.	MONTH.	Normal velocity. Miles in 24 hours.	Actual velocity. Miles in 24 hours.	Variation. Miles in 24 hours.	Variation of rainfall over India.
					Inches.
1895	June	221	201	−20	+0·09
	July	199	160	−39	−0·67
	August	170	153	−17	−0·09
	September	134	122	−12	−1·27
	October	112	99	−13	−0·25
1896	June	221	187	−34	+0·28
	July	199	175	−24	−0·39
	August	170	136	−34	+0·46
	September	134	112	−22	−2·98
	October	112	96	−16	−2·41
1897	June	221	193	−28	−0·73
	July	199	150	−49	−0·44
	August	170	158	−12	+2·46
	September	134	119	−15	+1·16
	October	112	95	−17	+0·31
1898	June	221	233	+12	−0·19
	July	199	211	+12	+0·45
	August	170	191	+21	+0·17
	September	134	123	−11	+1·32
	October	112	103	− 9	−0·38
1899	June	221	206	−15	+1·49
	July	199	168	−31	−2·12
	August	170	137	−37	−2·79
	September	134	113	−21	−2·32
	October	112	98	−14	−0·67

The preceding data show that though there are some exceptions stronger winds at Zanzibar are ordinarily accompanied with heavier rainfall over India. There were twelve months during which the wind's velocity exceeded the normal, and of these there were eleven with excessive against one only with deficient rain over India. On the other hand, there were twenty-three months, during which the trade winds at Zanzibar were lighter than usual, and while only eight of these had excessive, fifteen had deficient rain. There is thus, as stated above, a tendency to increased rainfall over India when the wind is abnormally strong at Zanzibar.

TABLE XLV.

Mauritius.

YEAR.	MONTH.	Normal velocity. Miles in 24 hours.	Actual velocity. Miles in 24 hours.	Variation. Miles in 24 hours.	Variation of rainfall over India.
					Inches.
1893	June	266	252	−14	+2·51
	July	281	282	+ 1	+007
	August	300	277	−23	−09·8
	September	277	266	−11	+1·27
	October	231	241	+10	+0·42
1894	June	266	248	−18	+1·14
	July	281	264	−17	+1·07
	August	300	268	−32	+0·66
	September	277	261	−16	+0·94
	October	231	215	−16	+2·81
1895	June	266	293	+27	+0·09
	July	281	225	−56	−0·67
	August	300	292	− 8	−0·09
	September	277	243	−34	−1·27
	October	231	199	−32	−0·25
1896	June	266	264	− 2	+0·28
	July	281	274	− 7	−0·39
	August	300	300	0	+0·46
	September	277	271	− 6	−2·98
	October	231	235	+ 4	−2·41
1897	June	266	288	+22	−0·73
	July	281	290	+ 9	−0·44
	August	300	341	+41	+2·46
	September	277	353	−24	+1·16
	October	231	254	+23	+0·31
1898	June	266	269	+ 3	−0·19
	July	281	295	+14	+0·45
	August	300	288	−12	+0·17
	September	277	259	−18	+1·32
	October	231	247	+16	−0·38
1899	June	266	245	−21	+1·49
	July	281	334	+53	−2·12
	August	300	331	+31	−2·79
	September	277	283	+ 6	−2·32
	October	231	223	− 8	−0·67

The preceding data show that during the thirty-five months under discussion there occurred only fourteen, during which the mean normal monthly velocity was exceeded, and of these fourteen months of increased velocity only six or about one-third had increased rainfall, so that with increased velocity of the South-East Trade current at Mauritius the chances are nearly 4:3 that the period will be one of lighter rainfall in India than the average. On the other hand, there were twenty months out of the thirty-five which had a lower mean monthly velocity than the average, and of these twenty months no less than twelve had increased rainfall over India, hence with lighter Trades than usual at Mauritius the chances are as 3:2 that the rainfall of the period will be heavier than the normal over India.

TABLE XLVI.

Seychelles.

Year.	Month.	Normal velocity. Miles in 24 hours.	Actual velocity. Miles in 24 hours.	Variation. Miles in 24 hours.	Variation of rainfall over India.
					Inches.
1894	June	258	301	+43	+1·14
	July	291	290	— 1	+1·07
	August	313	284	—29	+0·66
	September	288	277	—11	+0·94
	October	182	156	—26	+2·81
1895	June	258	287	+29	+0·09
	July	291	279	—12	—0·67
	August	313	328	+15	—0·09
	September	288	297	+ 9	—1·27
	October	182	240	+58	—0·25
1896	June	258	247	—11	+0·28
	July	291	292	+ 1	—0·39
	August	313	357	+44	+0·46
	September	288	301	+13	—2·98
	October	182	153	—29	—2·41
1897	June	258	170	—88	—0·73
	July	291	264	—27	—0·44
	August	313	272	—41	+2·46
	September	288	304	+16	+1·16
	October	182	193	+11	+0·31
1898	June	258	272	+14	—0·19
	July	291	275	—16	+0·45
	August	313	303	—10	+0·17
	September	288	275	—13	+1·32
	October	182	163	—19	—0·38
1899	June	258	271	+12	+1·49
	July	291	348	+57	—2·12
	August	313	336	+23	—2·79
	September	288	273	—15	—2·32
	October	182	188	+ 6	—0·67

The preceding data show that during the thirty months under review there were fifteen with a wind velocity above and fifteen with a wind velocity below the normal. Of the fifteen with an excess velocity there were six which had more rain than usual over India and nine with less; while of the fifteen months of low wind velocity nine had more and six less rain than usual. Hence with stronger South-East Trades than usual at the Seychelles the chances are as 3 : 2 that the accompanying rainfall over India will be lighter than usual, while with weaker South-East Trades than the average the chances are 3 : 2 that the accompanying rainfall will be above the normal.

If the information contained in the three preceding tables be compressed and smoothed the following results will be obtained:—

TABLE XLVII.

INCREASED VELOCITIES OR POSITIVE VARIATIONS.

Mauritius.		Zanzibar.		Seychelles.	
Velocity variation.	Rainfall variation over India.	Velocity variation.	Rainfall variation over India.	Velocity variation.	Rainfall variation over India.
Miles.	Inch.	Miles.	Inches.	Miles.	Inch.
0 to 9	−0·67	0 to 9	+0·01	0 to 9	−091
10 to 19	−0·22	10 to 19	+0·25	10 to 19	−0·95
20 to 29	−0·72	20 to 29	+0·56	20 to 29	−0·49
30 to 39	−0·81	30 to 39	+1·28	30 to 39	−0·14
40 to 49	−0·03	40 to 49	+1·53	40 to 49	+0·14
50 to 59	+0·17	50 to 59	+1·07	50 to 59	−0·19
		60 to 69	+0·76		

DECREASED VELOCITIES OR NEGATIVE VARIATIONS.

Mauritius		Zanzibar.		Seychelles.	
Velocity variation.	Rainfall variation over India.	Velocity variation.	Rainfall variation over India.	Velocity variation.	Rainfall variation over India.
Miles.	Inch.	Miles.	Inches.	Miles.	Inches.
0 to 9	− 0·36	0 to 9	−0·38	0 to 9	−0·15
10 to 19	+0·53	10 to 19	−0·40	10 to 19	+0·32
20 to 29	+0·34	20 to 29	−0·94	20 to 29	+0·16
30 to 39	−0·35 ?	30 to 39	−1·06	30 to 39	+0·75
40 to 49	−0·60 ?	40 to 49	−0·79	40 to 49	+1·60
50 to 59	−0·63 ?	50 to 59	−0·89		
		60 to 69	−0·98		

The preceding results are interesting as they show that in the case of Mauritius and the Seychelles increased velocity of the South-East Trades implies diminished rainfall over India and decreased velocity increased rainfall, while in the case of Zanzibar the conditions are reversed and the variations of the wind velocity and of rainfall, if they are related at all appear to be related directly.

It appears to the writer almost indisputable that if a relation existed between the variations in the direction and velocity of the South-East Trades and the variations of rainfall over India, such for example as that increased easting in the South-East Trades would accompany diminished rainfall over India, this relation would have been indicated when dealing with the means of the forty monsoon months which are contained in the seven monsoon seasons under review.

In this connection the following table, which is copied from the Annual Meteorological Review of India for 1900 (page 952) is of interest:—

Week.	1900	1899	1898	1897	1896	1895
	Hourly wind velocity in miles.	Hourly wind velocity in miles.	Hourly wind velocity in miles.	Hourly wind velocity in miles.	Hourly wind velocity in miles.	Hourly wind velocity in miles.
1st to 7th May	4·9	5·7	3·1	7·1	5·3	5·9
8th to 14th „	6·3	4·4	2·4	6·4	8·3	3·6
15th to 21st „	3·4	7·5	7·9	6·2	10·1	3·7
22nd to 28th „	5·4	19·5	7·5	6·9	9·4	6·4
29th May to 4th June	8·8	10·9	7·5	4·5	9·4	9·9
5th to 11th „	9·6	8·3	10·8	7·3	9·5	12·9
12th to 18th „	9·8	12·2	15·7	7·8	11·8	11·6
19th to 25th „	8·9	13·5	10·3	9·0	9·9	10·3
26th June to 2nd July	11·5	11·7	13·0	4·0	10·7	13·0
3rd to 9th „	9·8	15·9	13·9	11·3	12·6	9·7
10th to 16th „	13·9	14·8	12·2	10·0	11·9	11·3
17th to 23rd „	11·3	13·3	8·9	9·2	12·6	14·0
24th to 30th „	12·4	14·8	11·5	16·8	11·3	11·2
31st July to 6th August	12·9	13·0	12·4	11·5	15·8	13·2
7th to 13th „	13·8	14·2	12·3	9·9	14·0	11·7
14th to 20th „	15·5	15·3	14·3	13·1	13·7	16·0
21st to 27th „	14·7	15·8	12·3	12·8	15·5	14·0
28th Aug. to 3rd Sep.	12·2	12·2	9·9	8·9	16·1	12·0
4th to 10th „	10·7	15·0	13·4	16·7	10·8	13·3
11th to 17th „	11·5	12·8	12·5	10·9	13·3	12·9
18th to 24th „	14·3	7·5	10·3	13·0	12·8	12·1

The preceding data give a comparison, week by week, from the 1st of May to the end of September of the velocity of the air movement at Port Victoria for the six years 1895 to 1900. In the last year of the series there was a delay in the setting in of the

south-west monsoon and this setting in was practically coincident with the rise of the air movement at the Seychelles to 12 or 13 miles per hour on July 16th, but in the preceding year (1899) the rise of the air movement to 12 miles per hour occurred on the 18th June shortly after which date the drought of that year began to disclose itself. Hence when dealing with weekly data there exists the same difficulty in reconciling the march of the two phenomena as when dealing with monthly means.

It has, however, been suggested that dealing with monthly means is too rough a method to bring out this relation. Selected periods have accordingly been investigated during which the rainfall over India was generally heavier and more extensive, and others when the general rainfall was lighter and less extensive than usual. The actual wind directions and velocities recorded in the South-East Trades region during these periods have been extracted with the result that, while the velocity of the South-East Trades was generally slightly lower during breaks in the rains, and generally higher during periods of general rain, than the average, there existed no apparent connexion between the wind's direction and the variations in the rainfall.

Following the same system as in the case of the land observatories the next subjects for consideration are the wind's direction and force in Equatorial regions as derived from ships' observations. This is shown in the following sections :—

Observations recorded on boardships.

TABLE XLVIII.

YEAR.	MEAN WIND DIRECTION DATA OF THE EQUATORIAL REGIONS BETWEEN LATS. 4°N. AND 12°S. AND LONGS. 40° AND 80°E.						
	May.	June.	July.	August.	September.	October.	Season.
	°	°	°	°	°	°	°
1893 . . .	S 51 E	S 19 E	S 13 W	S 35 E	S 34 E	S 20 E	S 26 E
1894 . . .	S 25 E	S 18 E	S 33 E	S 18 E	S 11 E	S 32 E	S 23 E
1895 . . .	S 17 E	S 3 W	S 25 E	S 39 E	S 22 E	S 16 E	S 20 E
1896 . . .	S 33 E	S 6 E	S 9 E	S 30 E	S 24 E	S 65 E	S 28 E
1897 . . .	S 1 W	S 5 E	S 20 E	S 30 E	S 11 E	S 4 E	S 12 E
1898 . . .	S 22 E	S 11 E	S 7 E	S	S 13 E	S 37 W	S 3 E
1899 . . .	S 11 E	S 5 E	S 26 E	S 28 E	S 18 W	S 28 E	S 14 E
Mean . . .	S 23 E	S 9 E	S 15 E	S 26 E	S 15 E	S 19 E	S 18 E

From the above the following table has been constructed :—

TABLE XLIX.

YEARS.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	Mean.
Mean wind direction (May to October) for Equatorial Belt.	S 26° E	S 23° E	S 20° E	S 28° E	S 12° E	S 3° E	S 14° E	S 18° E
Departure from normal (Easterly deflection).	+8°	+5°	+2°	+10°	−6°	−15°	−4°	
Rainfall variation over India.	+4·88″	+6·07″	−2·63″	−5·33″	+2·40″	+0·69″	−6·49″	
Mean wind direction (May to October) South-East Trades (See Table XXXVII.)	S 45°E	S 39°E	S 32°E	S 38°E	S 38°E	S 39°E	S 32°E	S 38°E
Departure from normal or easterly deflection.	+7°	+1°	−6°	0	0	+1°	−6°	...

As was the case with the returns from the three land observatories there is no apparent connexion between the wind's direction in the Equatorial Belt and the variation of the monsoon rainfall over India. There are four seasons during which the me an direction of the Trades was more easterly than the normal, and in two of these years the rainfall was excessive, in one very deficient, and in one moderately deficient, while there were three years in which the wind was less easterly than usual, in two of which the rainfall was excessive and in one largely deficient. The above table simply supports the statement made when discussing the observations of the three land observatories that there is no direct relation between the wind's direction and the variations of the Indian rainfall. The question is one of considerable importance and hence the following table, giving monthly data of the mean wind direction over the Equatorial Belt derived from ships' observations, has been constructed :—

TABLE L.

YEAR.	MONTH.	Normal mean wind direction.	Actual mean wind direction.	Easterly deflection.	Rainfall variation over India.
		°	°	°	Inches.
1893	June	S 9 E	S 19 E	+10	+2·51
	July	S 15 E	S 13 W	—28	0·07
	August	S 26 E	S 35 E	+ 9	—0·98
	September	S 15 E	S 34 E	+19	+1·27
	October	S 19 E	S 20 E	+ 1	+0·42
1894	June	S 9 E	S 18 E	+ 9	+1·14
	July	S 15 E	S 33 E	+18	+1·07
	August	S 26 E	S 18 E	— 8	+0·66
	September	S 15 E	S 11 E	— 4	+0·94
	October	S 19 E	S 32 E	+13	+2·81
1895	June	S 9 E	S 3 W	—12	+0·09
	July	S 15 E	S 25 E	+10	—0·67
	August	S 26 E	S 39 E	+13	—0·09
	September	S 15 E	S 22 E	+ 7	—1·27
	October	S 19 E	S 16 E	— 3	—0·25
1896	June	S 9 E	S 6 E	— 3	+0·28
	July	S 15 E	S 9 E	— 6	—0·39
	August	S 26 E	S 30 E	+ 4	+0·46
	September	S 15 E	S 24 E	+ 9	—2·98
	October	S 19 E	S 65 E	+46	—2·41
1897	June	S 9 E	S 5 E	— 4	—0·73
	July	S 15 E	S 20 E	+ 5	—0·44
	August	S 26 E	S 30 E	+ 4	+2·46
	September	S 15 E	S 11 E	— 4	+1·16
	October	S 19 E	S 4 E	—15	+0·31

TABLE I.—*concld.*

YEAR.	MONTH.	Normal mean wind direction.	Actual mean wind direction.	Easterly deflection.	Rainfall variation over India.
		°	°	°	Inches.
1898	June	S 9 E	S 11 E	+ 2	—0·19
	July	S 15 E	S 7 E	— 8	+0·45
	August	S 26 E	S	—26	+0·17
	September	S 15 E	S 13 E	— 2	+1·32
	October	S 19 E	S 37 W	—56	—0·38
1899	June	S 9 E	S 5 E	— 4	+1·14
	July	S 15 E	S 26 E	+11	—2·12
	August	S 26 E	S 28 E	+ 2	—2·79
	September	S 15 E	S 18 W	—33	—2·32
	October	S 19 E	S 28 E	+ 9	—0·67

The preceding data show that over the Equatorial Belt the variations of the winds and of the rainfall exhibit the following relations:—

(1) Increased easting accompanied with diminished rain over India . 11 months.
(2) Increased easting accompanied with increased rain over India . 8 „
(3) Diminished easting accompanied with diminished rain over India . 5 „
(4) Diminished easting accompanied with increased rain over India . 11 „

The above shows very similar results to those obtained from the records of the three land observatories, and there appears to be no systematic connexion between the phenomena.

Carrying the investigation into the wind's force (Beaufort scale) over the Equatorial Belt the following table has been constructed:—

TABLE II.

YEAR.	MEAN WIND FORCE DATA OF THE EQUATORIAL REGIONS BETWEEN LATS. 4° N. AND 12° S. AND LONGS. 40° AND 80° E.					
	May.	June.	July.	August.	September.	October.
1893	2·9	3·4	4·4	4·2	3·4	3·2
1894	3·3	3·0	3·7	3·4	3·4	3·1
1895	2·7	3·8	3·6	3·7	3·7	3·5
1896	3·1	4·0	4·0	3·9	3·5	3·4
1897	3·5	3·5	3·7	3·6	3·7	3·5
1898	3·2	3·3	3·8	4·1	3·5	3·6
1899	3·2	4·2	4·1	3·9	3·4	3·2
Mean	3·1	3·6	3·9	3·8	3·5	3·4

From the above the following statement has been prepared showing the variations of the wind force (Beaufort's scale) in the Equatorial Belt and the monsoon rainfall variations in India :—

TABLE LII.

YEARS.	1893	1894	1895	1896	1897	1898	1899	Mean.
Mean wind force (Beaufort's scale) for May to October for Equatorial Belt.	3·6	3·3	3·5	3·7	3·6	3·6	3·7	3·7
Departure from normal	—·1	—·4	—·2	0	—·1	—·1	0	
Rainfall variation over India . . .	+4·88″	+6·07″	—2·63″	—5·33″	+2·40″	+0·69″	—6·49″	

The most marked feature in the wind force is the remarkable steadiness of the strength of the winds in the seven monsoon seasons. The largest variations from the normal occurred in the years 1894 and 1895. And it is noticeable that in 1899 when the rainfall failure was so extraordinarily large the wind velocity in the Equatorial Belt was exactly normal.

Leaving the seasonal values and dealing with the returns of each month of the seven monsoon seasons the following table has been constructed :—

TABLE LIII.

YEAR.	MONTH.	Normal wind force.	Actual wind force.	Variation.	Variation of rainfall over India.
					Inches.
1893	June	3·6	3·4	—·2	+2·51
	July	3·9	4·4	+·5	+0·07
	August	3·8	4·2	+·4	—0·98
	September	3·5	3·4	—·1	+1·27
	October	3·4	3·2	—·2	+0·42
1894	June	3·6	3·0	—·6	+1·14
	July	3·9	3·7	—·2	+1·07
	August	3·8	3·4	—·4	+0·66
	September	3·5	3·4	—·1	+0·94
	October	3·4	3·1	—·3	+2·81
1895	June	3·6	3·8	+·2	+0·09
	July	3·9	3·6	—·3	+0·67
	August	3·8	3·7	—·1	—0·09
	September	3·5	3·7	+·2	—1·27
	October	3·4	3·5	+·1	—0·25
1896	June	3·6	4·0	+·4	+0·28
	July	3·9	4·0	+·1	—0·39
	August	3·8	3·9	+·1	+0·46
	September	3·5	3·5	0	—2·98
	October	3·4	3·4	0	—2·41

TABLE LIII—*concld.*

YEAR.	MONTH.	Normal wind force.	Actual wind force.	Variation.	Variation of rainfall over India.
					Inches.
1897	June	3·6	3·5	—·1	—0·73
	July	3·9	3·7	—·2	—0·44
	August	3·8	3·6	—·2	+2·46
	September	3·5	3·7	+·2	+1·16
	October	3·4	3·5	+·1	+0·31
1898	June	3·6	3·3	—·3	—0·19
	July	3·9	3·8	—·1	+0·45
	August	3·8	4·1	+·3	+0·17
	September	3·5	3·5	0	+1·32
	October	3·4	3·6	+·2	—0·38
1899	June	3·6	4·2	+·6	+1·14
	July	3·9	4·1	+·2	—2·12
	August	3·8	3·9	+·1	—2·79
	September	3·5	3·4	—·1	—2·32
	October	3·4	3·2	—·2	—0·67

The table given above shows that out of the thirty-five months under discussion there were fifteen during which the South-East Trades were stronger than usual and of these fifteen there were eight with heavier rain and seven with lighter rain than usual; there were seventeen months with lighter Trades than usual and of these seventeen there were ten with heavier and seven with lighter rain than the average. These figures show that there exists no definite relation between the strength of the winds in the Equatorial Belt and the variations of the rainfall over India.

ARABIAN SEA.

WIND DIRECTION.

The following table shows the mean monthly wind direction derived from ships' observations over the Arabian Sea for the monsoon months of each year:—

TABLE LIV.

YEAR.	MEAN WIND DIRECTION DATA FOR THE WHOLE ARABIAN SEA AREA BETWEEN LATS. 4° N. AND 24° N. AND LONGS. 40° AND 80° E.						
	May.	June.	July.	August.	September.	October.	Season.
	°	°	°	°	°	°	°
1893	S 56 W	S 57 W	S 56 W	S 59 W	S 66 W	N 18 E	S 66 W
1894	S 60 W	S 58 W	S 57 W	S 60 W	S 66 W	N 41 E	S 65 W
1895	S 76 W	S 52 W	S 58 W	S 60 W	S 74 W	N 20 E	S 74 W
1896	S 64 W	S 59 W	S 56 W	S 62 W	S 71 W	N 35 E	S 67 W
1897	S 83 W	S 62 W	S 61 W	S 65 W	S 68 W	N 4 E	S 79 W
1898	S 77 W	S 69 W	S 62 W	S 63 W	S 67 W	N 9 E	S 77 W
1899	S 68 W	S 56 W	S 62 W	S 64 W	S 64 W	N 9 E	S 73 W
Mean	S 69 W	S 59 W	S 59 W	S 62 W	S 68 W	N 19 E	S 71 W

Collecting the above data under the head of the different seasons the following table has been constructed :—

TABLE LV.

YEAR.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
Mean wind direction (May to October) for Arabian Sea.	S 66° W	S 65° W	S 74° W	S 67° W	S 79° W	S 77° W	S 73° W
Variation from normal (westerly deflection.)	−5°	−6°	+3°	−4°	+8°	+6°	+2°
Rainfall variation over India	+4·88″	+6·07″	−2·63″	−5·33″	+2·40″	+0·69″	−6·49″

The preceding data show that the mean monthly direction of the South-West monsoon winds is nearly as steady as the direction of the South-East Trades from one season to another. The largest departures from the normal were +8° in 1897 and −6° in 1894. There were three years in which the wind during the monsoon was less westerly than the average and of these years, two, *viz.*, 1893 and 1894, had excessive monsoon rain while the third, *viz.*, 1896, had very deficient monsoon rains. In four years the winds were more westerly than usual and of these, two years, *viz.*, 1895 and 1899, had short to very short rains and the other two years, *viz.*, 1897 and 1898 had excessive to normal rains.

The data show that the variations of the South-West monsoon winds are quite inadequate to explain the large variations of rainfall shown in the last line of the above table and also that variations in the wind direction of a similar character are at times accompanied with an excess and at times with a deficiency of the monsoon rainfall over India.

WIND FORCE.

The following table gives the mean monthly wind force (Beaufort's scale) over the Arabian Sea for the monsoon months of each year :—

TABLE LVI.

YEAR.	MEAN ACTUAL WIND FORCE DATA OF THE WHOLE ARABIAN SEA AREA BETWEEN LATS. 4° N. AND 24° N. AND LONGS. 40° AND 80° E.						
	May.	June.	July.	August.	September.	October.	Season.
1893	3·5	4·0	4·4	4·1	3·3	2·8	3·7
1894	3·0	4·3	4·4	3·9	3·1	2·7	3·6
1895	2·9	4·3	4·4	3·8	3·0	2·9	3·6
1896	3·2	4·4	4·6	4·2	3·1	2·6	3·7
1897	2·8	4·2	4·4	4·1	3·3	2·4	3·5
1898	2·8	4·3	4·4	3·9	3·0	2·6	3·5
1899	3·2	4·5	4·3	3·9	3·2	2·8	3·7
Mean	3·1	4·3	4·4	4·0	3·1	2·7	3·6

Collecting the above data under the heading of the different seasons the following table has been constructed :—

TABLE LVII.

YEARS.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
Mean wind force	3·7	3·6	3·6	3·7	3·5	3·5	3·7
Variation from normal . . .	+ ·1	0	0	+ ·1	— ·1	— ·1	+ ·1
Rainfall variation over India . .	+4·88″	+6·07″	—2·63″	—5·33″	+2·40″	+0·69″	—6·49″

The preceding data show that taking each monsoon season as a whole the variations in the force of the wind over the Arabian Sea are exceedingly small. In the "Discussion on the failure of the rains in 1899," it was stated that the force of the wind was a trifle lower than usual throughout the monsoon of 1899; but fuller information has altered this, and the present investigation has shown that 1899, which was a year of phenomenally light rainfall over India, had winds a trifle above the normal over the Arabian Sea. The other years with stronger monsoon winds than usual were 1896 when the rainfall variation also showed a large deficiency (—5·33 inches) and 1893 when the rainfall variation over India was +4·88 inches. In 1894 and 1895 there was no variation from the normal in the force of the monsoon winds, while the rainfall variations over India were in 1894 +6·07 inches and in 1895 —2·63 inches. In the two monsoon seasons of 1897 and 1898 the mean force of the wind was ·1 less than usual, and in both these years the monsoon rainfall was in moderate to slight excess.

It is impossible to draw any other conclusion from the above data except that the monsoon winds are extraordinarily steady in each season, and that the variations in the rainfall over India are carried out quite irrespective of the small variations in the direction and force of the winds over the Arabian Sea which the two preceding sections have disclosed.

In the preceding pages I have examined most carefully for the past seven monsoon seasons the whole of the meteorological data which can reasonably be supposed to influence the rainfall of the Indian area. I have examined the seasonal and monthly variations in the direction and in the force of the winds over the South-East Trades region over the Equatorial Belt and over the Arabian Sea, and the examination has disclosed only minute irregular variations which appear wholly inadequate to account for the recorded vicissitudes of the Indian rainfall. I have examined the seasonal and monthly barometric differences or gradients over the South-East Trades region and over the Arabian Sea, and I can find no relation between the variations in the barometric pressure differences and the variations of the Indian rainfall. Finally I have examined the Indian rainfall in relation to certain large pressure oscillations which the barometric records disclosed. In this connection and in this connection alone, was an agreement established, the observations apparently showing that the rainfall of the Trades-monsoon area was, in its main features, a function of these pressure oscillations. Super-imposed on these major pressure oscillations were minor oscillations, some indigenous to the southern and some indigenous to the northern portions of the area. These minor oscillations undoubtedly

impressed their mark on the rainfall, but they have in the present paper been left out of consideration and both the rainfall and the oscillations have been considered only from the point of view of the larger and more massive changes which the observations disclosed. These pressure oscillations were general throughout the whole Trades-monsoon area. The epochs of the maxima and of the minima occurred at about the same time throughout the whole area though perhaps earlier by a month or two in the South-East Trades region than in the monsoon area, and, on the whole, the amplitudes of the oscillations, were the same in Lat. 30°S. as in Lat. 30°N. The effects of the oscillations on the rainfall were reversed in the two hemispheres, the rising portions of the oscillations having been accompanied with excessive rain in the southern and with deficient rain in the northern hemisphere, and the falling portions of the oscillations with deficient rain in the southern and with excessive rain in the northern hemisphere, but the relation of the oscillations to the rainfall was as clear in the one case as in the other.

How these oscillations originated and what determined their magnitude, duration and velocity of movement I am unable to say. They were apparently as marked in the atmosphere at an elevation of 7,000 feet as at the earth's surface and as large in Lat. 30°S. as in Lat. 30°N., and their effects on the rainfall were unmistakable.

It was suggested by the writer in the discussion on the failure of the south-west monsoon rains in 1899 that the excess of pressure, which is so commonly a characteristic of a period of deficient rain, and was especially strongly pronounced over India in 1899 is in itself a result or concomitant of this deficient rainfall. It was pointed out that an absence of ascensional movement in the upper atmosphere would be occasioned by the absence of condensation and by the non-precipitation of rain, and that this absence of ascensional movement would be manifested by an excess of pressure at and near the earth's surface. Further investigation appears to show that it is possible a part of the excess under these conditions may be accounted for in this manner. It will be seen from the curves in Plate LXXVII that the pressure abnormals in the great excess of 1899 were greater over India than they were over the South-East Trades region, and to the extent of this difference it is possible that the excess of pressure was due to the above cause, but that the whole excess was the result of the failure of the rainfall appears to be negatived on the following grounds (1) the excess of pressure was practically as strongly marked over the South-East Trades region (where the rainfall was heavy and prolonged) as over India; (2) the rise of pressure which culminated in the large excess commenced in the South-East Trades region (where the rainfall was heavy), and thence progressed northward to the Indian region (where the rainfall was deficient);* and (3) the increase of pressure which culminated in the large excess of pressure had commenced over India as

* I have carefully examined the whole of the evidence for the northward movement of an area of high or excess pressure across the Equator to the Indian region. It rests solely upon the mean of seven observations taken on board three vessels in May 1899, which have been twice corrected. The mean of these corrected observations are taken for three squares and assumed to give the mean pressure of these three areas for the month of May. The results are opposed to those of the Zanzibar observations, which show that pressure at Zanzibar was in May ·006" below the normal.—J. E.

early as February, and had already manifested itself as an excess over India in June, in which month the actual rainfall of India was above the normal.†

If the excess of pressure at this time had been a result of deficient rain and of the absence of ascensional movement, then both the rise of pressure and the excess of pressure should have been manifested subsequent to June, 1899, as it was not till that month that the failure of the rains disclosed itself.

The fact that the rise of pressure and the excess of pressure both appeared first over the area of excessive rain in the South-East Trades region, and thence progressed northward to the area of deficient rain over India; the fact that the rise of pressure and the excess of pressure preceded and did not follow the cessation of rain in India, appear to show as conclusively, as in meteorology it is possible to show any thing in the nature of proof, that the absence of rain and the excess of pressure did not bear the respective relations of cause and effect. Whether the reverse relationship existed it is impossible to determine, but, on the whole, the evidence is in favour of the rapid rise of pressure having been directly or indirectly the *reason* of the absence of rain.

With the object of determining whether these pressure oscillations could be reconciled with the variations of any other element, the pressure curve given in Plate LXXVII was sent to Mr. A. F. Moos at the Colaba Observatory. His reply was "I presume your pressure curves show abnormal surges giving maxima in August 1893, April 1897 and August 1899, and minima in August 1894 and November 1898 which you wish to explain".

"The declination and vertical force traces practically show no such pulses, but the horizontal force distinctly exhibits similar fluctuations. Whether there is any close coincidence in these pulses and those shown by your pressure curves is extremely doubtful, but I send you the figures and calculations with full details for what they are worth".

The following are the magnetic variations supplied by Mr. Moos:—

TABLE I.—*Sums without regard to signs of excesses of mean diurnal variation of Horizontal Force in C. G. S. units for each month from 1893 to 1899.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual means.	Ratios of annual means to the mean of all the years.
1893	·00274	·00354	·00458	·00466	·00474	·00480	·00442	·00423	·00330	·00381	·00329	·00329	·00395	1·30
1894	·00270	·00363	·00392	·00430	·00400	·00438	·00434	·00332	·00331	·00357	·00370	·00261	·00365	1·20
1895	·00221	·00347	·00387	·00401	·00402	·00383	·00341	·00310	·00304	·00306	·00320	·00245	·00331	1·09
1896	·00232	·00272	·00362	·00361	·00359	·00323	·00317	·00229	·00268	·00328	·00268	·00216	·00295	0·97
1897	·00280	·00278	·00342	·00303	·00273	·00254	·00272	·00241	·00263	·00245	·00230	·00276	·00271	0·89
1898	·00179	·00253	·00315	·00310	·00270	·00296	·00263	·00195	·00196	·00234	·00258	·00189	·00246	0·81
1899	·00150	·00188	·00280	·00300	·00256	·00150	·00265	·00248	·00201	·00198	·00233	·00176	·00220	0·73
Average monthly means.	·00229	·00294	·00362	·00367	·00348	·00333	·00333	·00283	·00271	·00293	·00287	·00242	·00303	

† The following gives the mean monthly variations of pressure from the normal in the Indian Land Area during the period January to June 1899:—

January 1899	—·003
February "	—·040
March "	—·010
April "	—·001
May "	—·019
June "	+·009

The variations of pressure during the period were considerable in amount, and were almost certainly related to other meteorological actions as well as to rainfall.—J. E.

TABLE II.—*Normal values of Table I for each month from 1893 to 1899.*
(Normal value = Average monthly mean × ratio of corresponding annual mean.)

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1893	·00298	·00382	·00471	·00477	·00452	·00433	·00433	·00368	·00352	·00381	·00373	·00315
1894	·00275	·00353	·00434	·00440	·00418	·00400	·00400	·00340	·00325	·00352	·00344	·00290
1895	·00250	·00320	·00395	·00400	·00379	·00363	·00363	·00308	·00295	·00319	·00313	·00264
1896	·00222	·00285	·00351	·00356	·00338	·00323	00323	·00275	·00263	·00284	·00278	·00235
1897	·00204	·00262	·00322	·00327	·00310	·00296	·00296	·00252	·00241	·00261	·00255	00215
1898	·00185	·00238	·00293	·00297	00282	·00270	·00270	·00229	·00220	·00237	·00232	·00196
1899	·00167	·00215	·00264	·00268	·00254	·00243	·00243	·00207	·00198	00214	·00210	·00177

TABLE III.—*Abnormal values of Table I, or abnormals of mean Ranges of Horizontal Force.*
(Abnormal values = Numbers in Table I *minus* numbers in Table II.)

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1893	—·00024	—·00028	—·00013	—·00011	+·00027	+·00047	+·00009	+·00055	—·00022	·00000	—·00044	+·00014
1894	—·00005	+·00010	—·00042	—·00010	—·00018	+·00038	+·00034	—·00008	+·00006	+·00005	+·00026	—·00029
1895	—·00029	+·00027	—·00008	+·00001	+·00023	+·00025	—·00022	+·00002	+·00009	—·00013	+·00007	—·00019
1896	+·00010	—·00013	+·00011	+·00005	+·00021	·00000	—·00006	—·00046	+·00005	+·00044	—·00010	—·00019
1897	+·00076	+·00016	+·00020	—·00024	—·00037	—·00042	—·00024	—·00011	+·00022	—·00016	—·00025	+·00061
1898	—·00006	+·00015	+·00022	+·00013	—·00012	+·00026	—·00007	—·00034	—·00024	—·00003	+·00026	—·00007
1899	—·00017	—·00027	+·00016	+·00032	+·00002	—·00093	+·00022	+·00041	+·00003	—·00016	+·00023	—·00001

The figures given in Table III of the above have been utilised to draw the curve given in the lower part of Plate LXXVI and this curve shows that the horizontal force fluctuations as recorded at Kolaba follow a course similar to that given by the abnormal pressure variations. It will be noticed that throughout the greater part of the curves the likeness is very marked. There are, however, certain large variations in the magnetic curve which are not reproduced in the pressure curve—more particularly in June 1899. All these departures require investigation and consideration but, in the mean time, it is sufficient to draw attention to the general agreement between the pressure and the magnetic curves for the period under review.

Note.—The above discussion was prepared during 1900 at the close of the seven years to which it refers, but owing to press of publications in the Meteorological Department its appearance was delayed till the present time. In the discussion I have carefully adhered to the period under review and have avoided any suggestion that the results therein obtained are applicable to all periods for the following reason. It happened that during the seven years the barometric oscillations were general over the whole Trades monsoon area, but it is clear from Mr. Eliot's paper already referred to and to a certain extent from the evidence of the first pressure oscillation that at times the oscillations are not homogeneous over all parts of the area, and when this is the case the conditions under which rain occurs require special investigation. The Indian rainfall of the past two years is an instance in point. In 1900 the monsoon rainfall was normal, while in 1901 it was in defect. At the same time pressure was falling over India, while it was practically steady over the Trades region.—W. L. D.,—5-3-02.

NOTE BY THE EDITOR.

Mr. Dallas handed this memoir to me in April, 1901. I was unable to send it for publication until the end of December, 1901.

Mr. Dallas corrected the first proof before he went on leave in March 1902. I had no opportunity of discussing the memoir with him as I was absent from Simla on inspection tour from the middle of December 1901 until the end of March 1902. I have hence in revising the second proof made purely verbal corrections, but left the arguments to stand as they were passed by Mr. Dallas.

It is necessary for me to point out that while admitting it gives a large amount of interesting and valuable information respecting a period characterized by very remarkable features in the Indian monsoon area I am unable to accept a portion of his data as being of sufficient value to be utilized for the comparisons he has made and that I am also unable to agree with several of his conclusions. It will be sufficient to give two or three examples.

Mr. Dallas works out the abnormal pressure variations of the land observatories and also of the ship observations and considers the parallelism between the results to be a strong evidence of the reality of these variations over the whole area. The evidence given by the ship observations is, however, not independent. The barometric readings on boardship are in the majority of cases very unsatisfactory and are corrected in various ways in order to fit them to the observations at the land stations which are almost invariably assumed to be correct. The corrected ship observations as the result of this method of correction hence necessarily agree with the land observations.

Again, Mr. Dallas bases certain conclusions on the comparison of the rainfall variations in the Indian area and the South-East Trades Region with the long period pressure oscillations. The rainfall means in the case of the Indian area are based on the returns of over 2,000 stations and probably represented the variations with approximate accuracy. In the case of the South-East Trades Region (covering an area at least five times the extent of India) they are based on the returns of three stations only and those in the outskirts of the area. It is, I think, dangerous to accept any conclusions based on the returns of these three stations as representative of the whole of that vast area, more especially when the extreme variability of rainfall is taken into consideration.

Again with respect to the abnormal rainfall in Central Africa in 1899. If I understand Mr. Dallas's argument correctly it is that there was no unusual diversion of the South-East Trades in that direction as shown by the available wind data. In the Annual Summary for 1899, I gave a part of the evidence on this point. I have since received evidence of phenomenal rainfall in that area in 1899. The mere fact of the occurrence of this rainfall is sufficient evidence of an unusual diversion of the Trades in that direction. Mr. Dallas uses a similar argument for the varying intensity of the monsoon current in different parts of India, and it appears to me to be a perfectly valid argument.

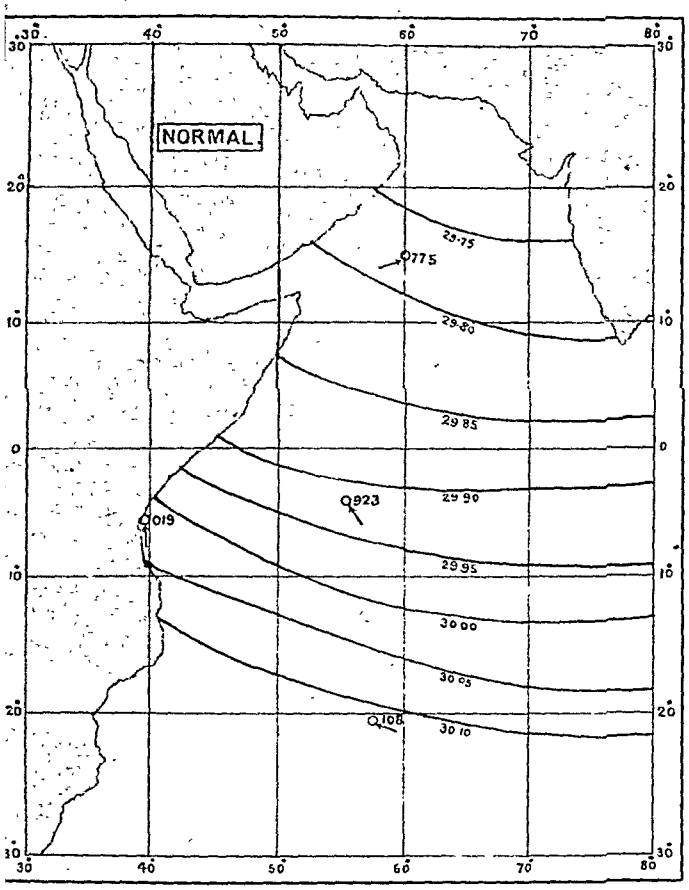
Mr. Dallas ascribes the deficient rainfall in India to the march of an area of high pressure or anticyclonic conditions northwards from the centre of the Indian Ocean to the centre and north of the Arabian Sea. I have examined the data and cannot find sufficient evidence for the existence of an area of high pressure in the Indian Ocean and its march northwards across the equator.

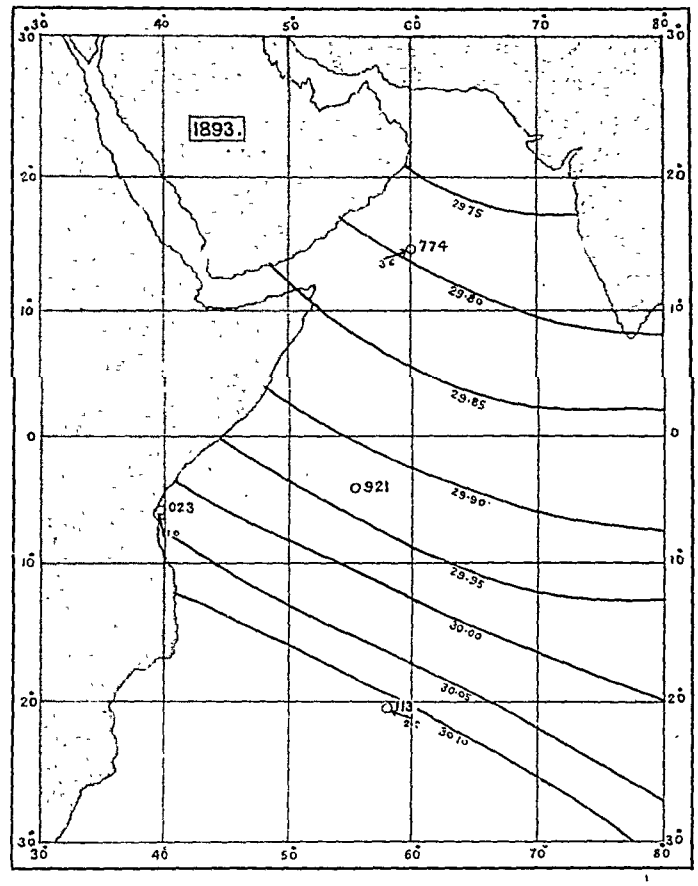
The low pressures in India before the advent of the monsoon are primarily a result of the air movement initiated by the great and increasing heat in the interior. After the advent of the monsoon low pressure conditions continue through June, July and August, the primary cause being not the thermal conditions but the rainfall. Larger rainfall than usual in India during the south-west monsoon, we know, accompanies lower pressure or negative pressure variations and less rainfall than usual positive variations. This is simply equivalent to the statement that a greater volume of ascensional movement accompanies increased rainfall and a smaller volume accompanies diminished rainfall. The variations of pressure during the monsoon season of 1899 in India and the Arabian Sea area are, so far as I can judge, in complete agreement with the above statement.

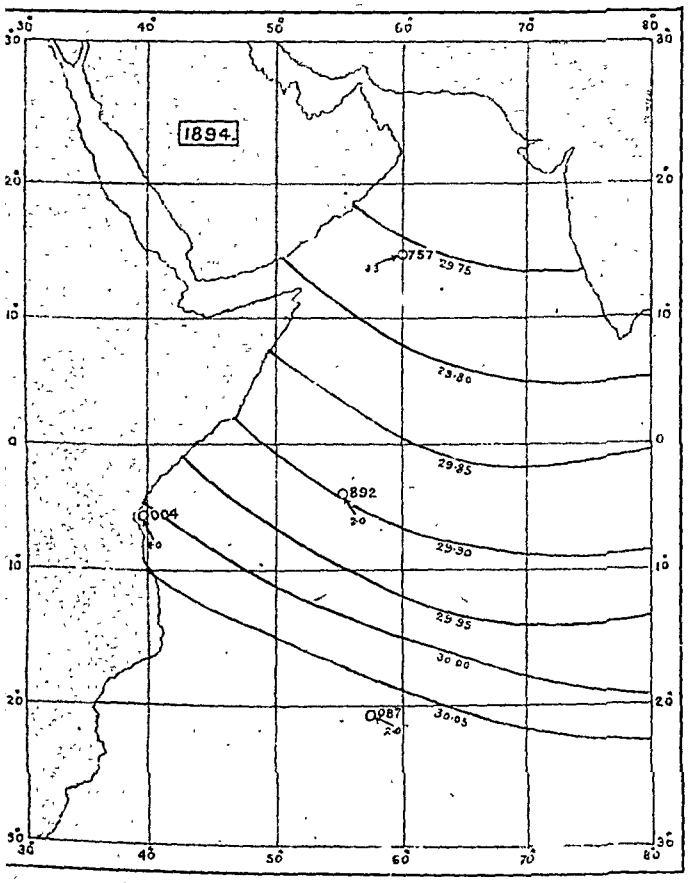
I am hence unable to accept Mr. Dallas's conclusion that the remarkable drought of the year 1899 was due to the antecedent march of an area of high pressure from the South-East Trades region across the equator into the Indian region.

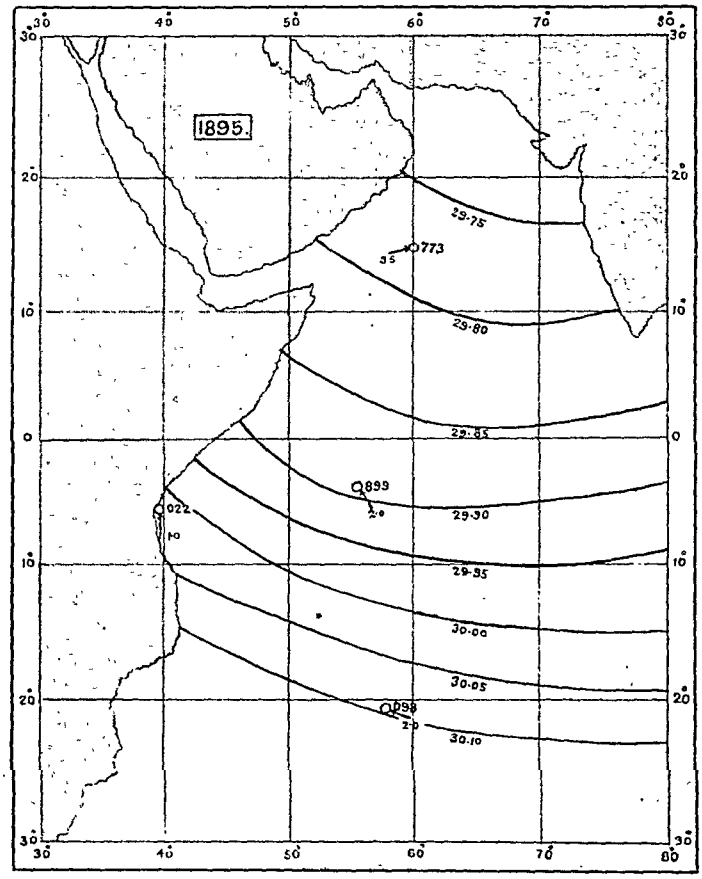
It also appears to me doubtful whether the results or conclusions based on an examination of the very abnormal period, 1893—1899, can be accepted as having the general application apparently claimed for them in the body of the memoir, but apparently to some extent withdrawn in the note on page 484.—J. E.

AVERAGES OF PRESSURE AND OF WIND DIRECTION AND FORCE OF EACH MONSOON SEASON.









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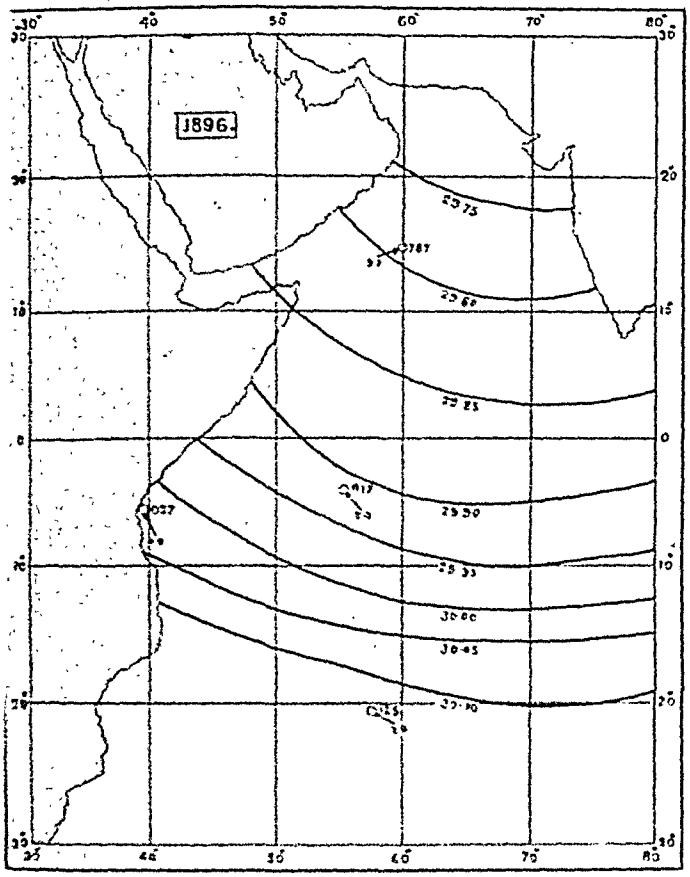
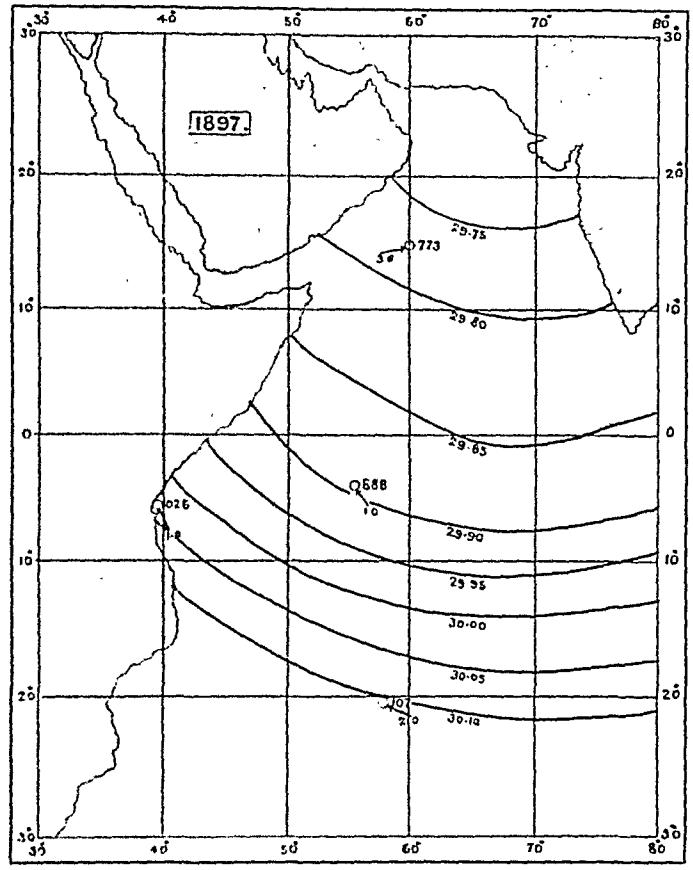
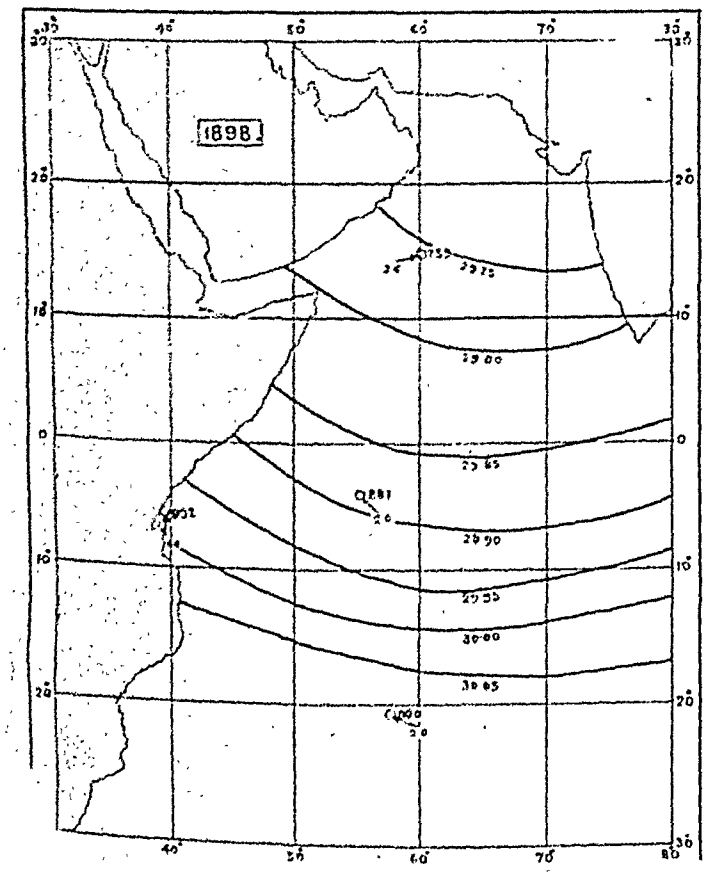
AVERAGES OF PRESSURE AND OF WIND DIRECTION AND FORCE OF EACH MONSOON SEASON.







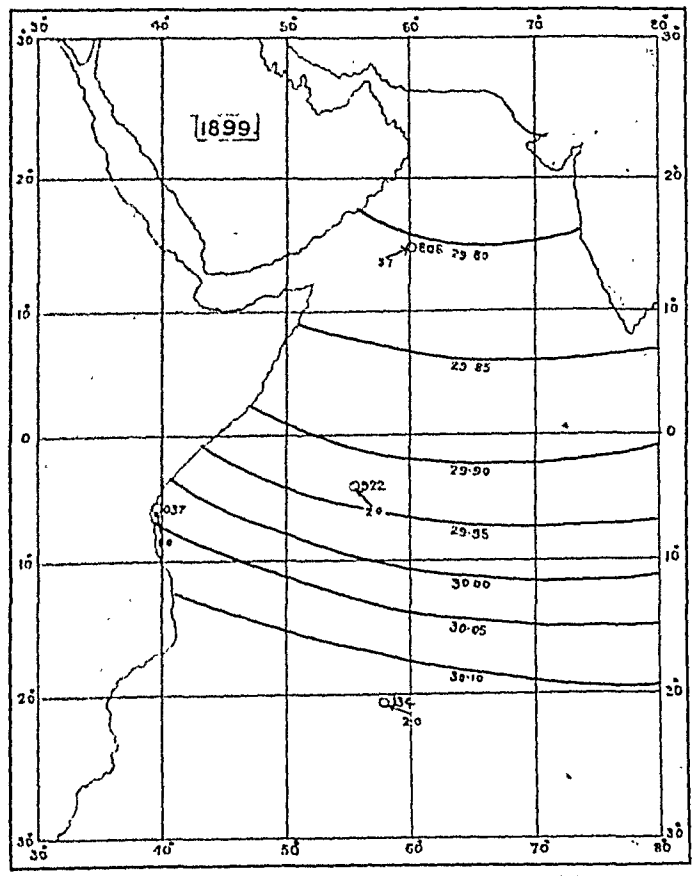


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Fig.1.

ACTUAL MEAN PRESSURE IN SOUTH-EAST TRADES REGIONS FOR EACH MONSOON SEASON 1893 TO 99.

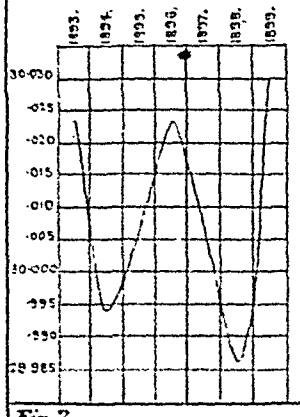

Fig.2.

ACTUAL MEAN PRESSURE IN EQUATORIAL BELT FOR EACH MONSOON SEASON 1893 TO 99

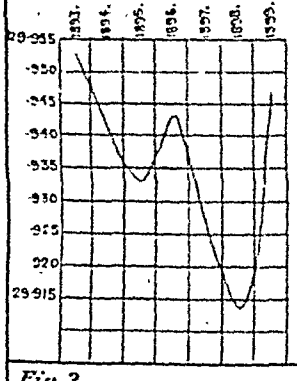

Fig.3.

ACTUAL MEAN PRESSURE IN SOUTH-EAST TRADES REGIONS FOR EACH MONSOON SEASON 1893 TO 99.

MAURITIUS.

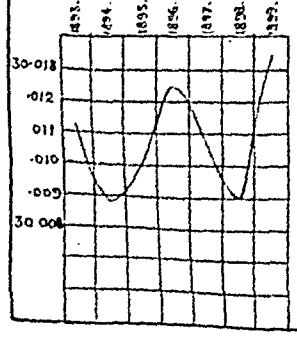

Fig.4.

ACTUAL MEAN PRESSURE IN SOUTH-EAST TRADES REGIONS FOR EACH MONSOON SEASON 1893 TO 99.

ZANZIBAR.

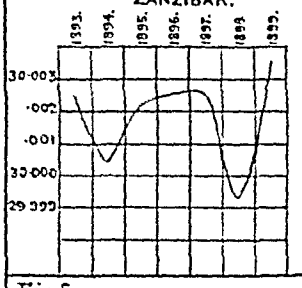

Fig.5.

ACTUAL MEAN PRESSURE IN SOUTH EAST TRADES REGIONS FOR EACH MONSOON SEASON 1893 TO 99.

SEYCHELLES.

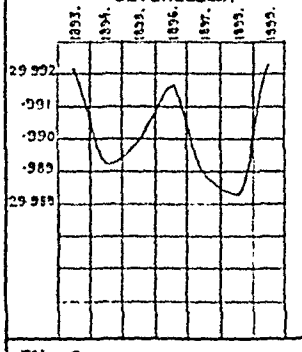

Fig.6.

ACTUAL MEAN PRESSURE IN ARABIAN SEA FOR EACH MONSOON SEASON 1893 TO 99.

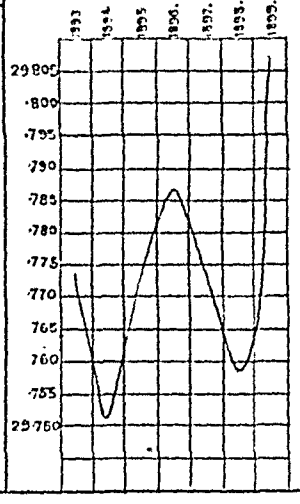

Fig.7.

ACTUAL MEAN PRESSURE VARIATION IN INDIA FOR EACH MONSOON SEASON 1893 TO 99.

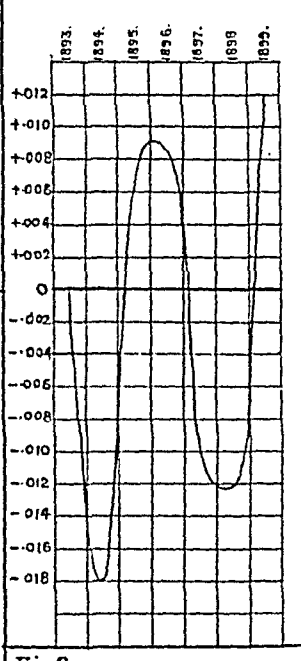

Fig.8.

ACTUAL MEAN PRESSURE AT NEWERA ELIYA FOR EACH MONSOON SEASON 1893 TO 99.

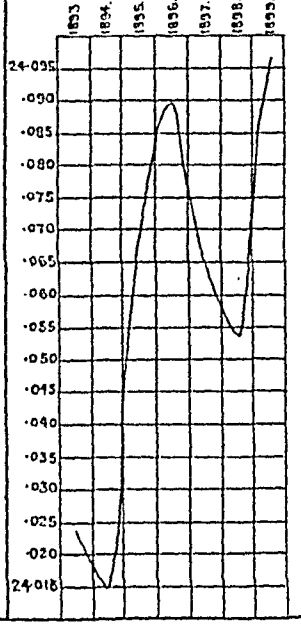

Fig.9.

ACTUAL MEAN PRESSURE AT DARJEELING FOR EACH MONSOON SEASON 1893 TO 99.

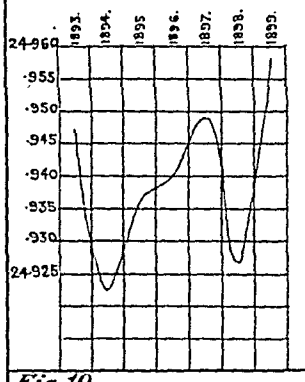

Fig.10.

ACTUAL MEAN PRESSURE AT WELLINGTON FOR EACH MONSOON SEASON 1893 TO 99.

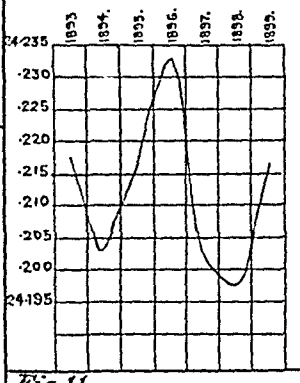

Fig.11.

ACTUAL MEAN PRESSURE IN SOUTH-EAST TRADES REGIONS FOR EACH HOT SEASON 1893-4 TO 1899-00.

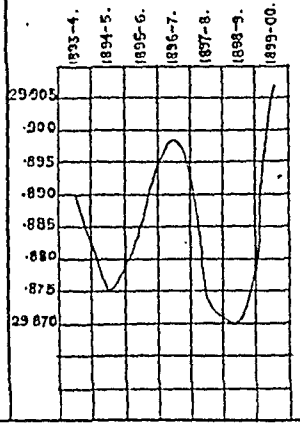

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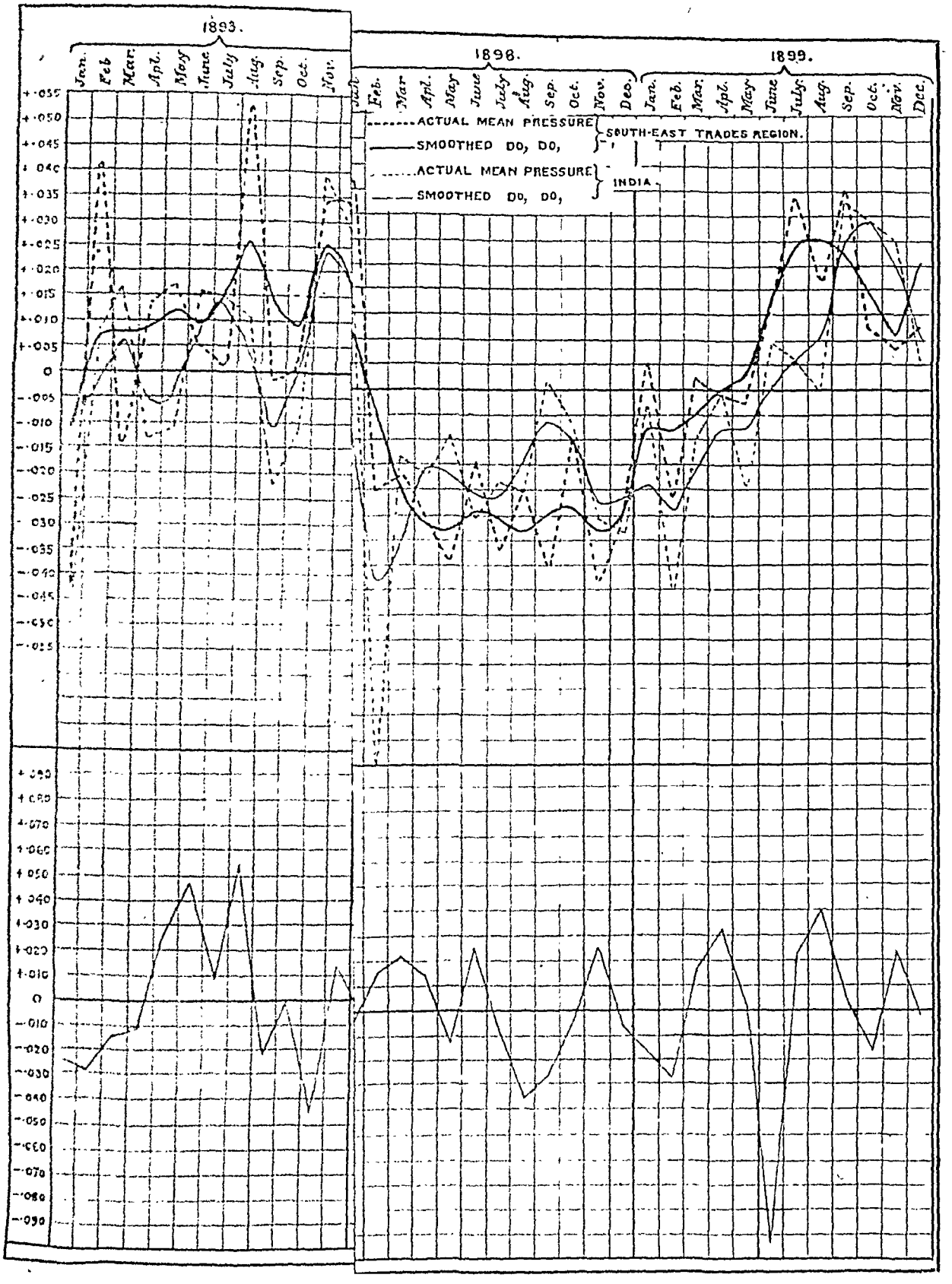
Plate LXXVII.



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